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EDITORIAL

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Prophylactic Odontotomy—*Hyatt*

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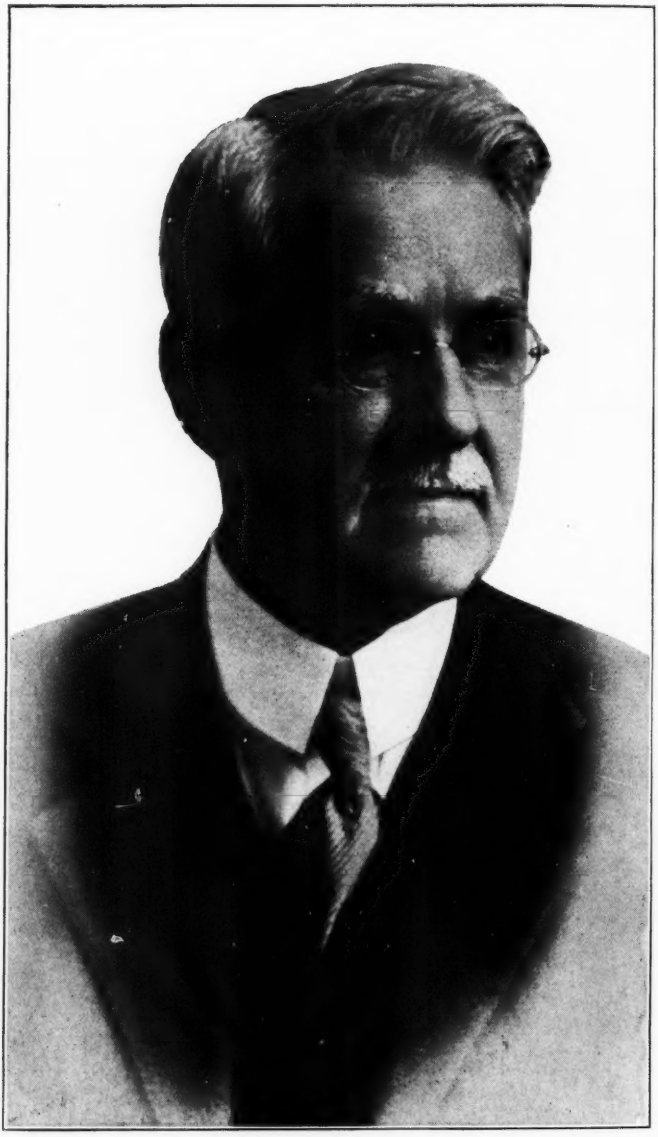
The Journal of the American Dental Association, Vol. XVII, No. 8. Published by the American Dental Association, 58 East Washington Street, Chicago, Ill. Yearly subscription, $2.50. Entered as second-class matter, May 1, 1928, at the post office at Chicago, Ill., under the act of Aug. 24, 1912. Published monthly.



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THOMAS L. GILMER, M.D., D.D.S., Sc.D., F.A.C.S., Chicago, Ill.
Guest of honor at the annual banquet of the Illinois State Dental Society, May 13, 1930.

THE JOURNAL
of the AMERICAN DENTAL ASSOCIATION
Vol. 17 AUGUST, 1930 No. 8

Original Communications

"AN ANALYSIS OF THE DEVELOPMENT OF THE ARTICULATOR"*

By ALFRED GYSI, D.D.S., Zurich, Switzerland

BECAUSE I have reason to believe that many of my friends in America have received my various contributions to the study of mandibular movements, their reproduction in articulators and their influence on the occlusal surfaces of artificial teeth with a certain degree of respect, it is only natural that I wish to correct certain statements by Rupert E. Hall in his recent references to me and to put the facts before the readers of THE JOURNAL for their information. I have therefore prepared the following reply: 1. Historical remarks. 2. The importance of the working condyle. 3. Dr. Hall's challenge on his own case. 4. Two-dimensional and three-dimensional articulators.

*A reply to an article published under this title by Hall, R. E.: J. A. D. A., 17:3 (Jan.) 1930.

HISTORICAL REMARKS (MISSTATEMENTS CORRECTED)

On page 13, the second column, Dr. Hall writes: "Snow's and Gysi's names have been so heralded that poor Walker's name, together with his work, seems to have been submerged in such depths as to be forgotten completely, and his work accredited to Gysi." The reason that Walker's work in 1896-1897 has been forgotten is that his articulator was never on the market; it was too complicated and its facebow too cumbersome. I always gave credit to Walker for having found the downward path of the condyle, although later it was proved that Balkwill in England published the downward movement of the condyle sixty-four years ago (1866)! On the other hand, I may say that I have never seen in any of Dr. Hall's writings that he has given me

credit for the use of my incisal guide pin, which he has used on all his articulators! I have never pretended to have found any condyle movement; I have always written that Bonwill found the forward movement, Walker the downward movement and Bennett the inward movement of the condyles. All I have claimed is that I was the first to build an arbitrary articulator which produces all three of these movements discovered by Bonwill, Walker and Bennett.

Dr. Hall further writes, on page 16, first column: "Luce . . . appears to be the first to claim patent rights to the improvement of an incisal pin support and guide." In fact, I was the first to claim patent rights on this improvement, but the patent was not granted, because the patent office contended that the Kerr articulator had a support pin behind the plaster models, and that therefore it was no invention to place this support pin in front of the plaster models. At any rate, it is a fact that I illustrated this incisal pin support in my book, "Problems of Articulation" (see Fig. 20), in 1908, in Berlin (Hirschwald); whereas, Luce's patent bears the date Nov. 28, 1911. This German book on "Problems of Articulation" was translated in the *Dental Cosmos* in January, 1910 (see Fig. 25), which is at least one year earlier than Luce's patent.

On page 18, first column, Dr. Hall writes: "The adjustable incisal guidance feature . . . belongs to me, as shown by the respective filing dates of the Snow and Hall patents covering adjustable incisal guidance." (Hall's patent was applied for in 1914 and granted in April, 1917.) To this, let me say that, in reality, Dr. Rumpel (Berlin) first suggested changing my rotation centers on the condyle chord into an adjustable guidance for the incisal pin. This sugges-

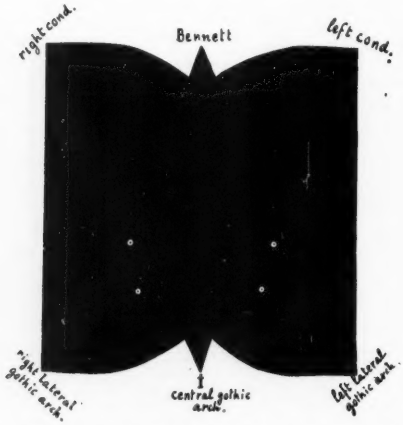


Fig. 1.—A piece of sheet metal to be used as a moving body in connection with Figures 2-12.

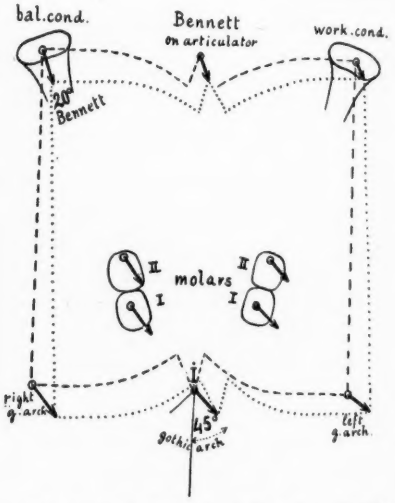


Fig. 2.—Moving body from Fig. 1 moved on a piece of white paper from the outline denoted by dashes (— — — —) to the outline denoted by dots (.....). The arrows mark the directions of the movements of the different points of the moving body.

tion was published in *Die Deutsche Monatsschrift für Zahnheilkunde,* June, 1913, and from that date on I made practical experiments with such an arrangement and showed a fully adaptable articulator with this adjustable incisor guidance in *Die Schweizerische Verteljahrsschrift für Zahnheilkunde,* 1915, on page 228; whereas, Hall's patent bears the date April, 1917.

In regard to this articulator of Dr. Hall's, he writes on page 19, first column: "The fact is that I first built adjustable articulators," and further: "The Hall adjustable articulator was also the first, to my knowledge, to embody the improvement of an adjustable incisal guide for reproducing the gothic arch movement of the incisor point with the incisal pin and guide. The principles of this guide are now *copied* and embodied in the trubyte and Wadsworth articulators." From the above-mentioned dates, it is evident that *I did not copy Dr. Hall's incisal guidance,* because my articulator with this arrangement was already on the market in 1914 and a paper on its use was published in 1915, which is two years before Hall's patent in April, 1917. Also, the condyle parts of my articulator of 1911 had an

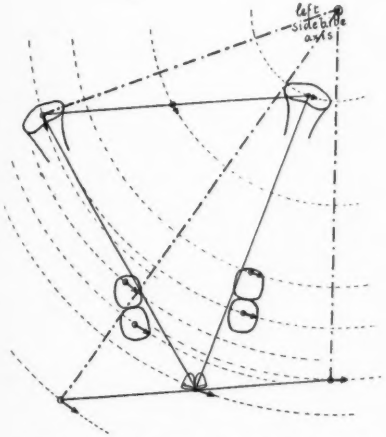


Fig. 3.—Drawing in which the dash-dotted lines (.—.—.—.—.) are at right angles to the corresponding three movements of Figure 2. The point where these right angles intersect is the common rotation center of all ten movements. As the mandible is a three-dimensional moving body, it rotates not around a center but around a common axis, and this axis pierces the plane laid over the condyles and the incisors at the spot where the radii of the movements intersect. All ten movements are concentric around this side-bite axis. The range of movement is in direct proportion to the distance from the side-bite axis.

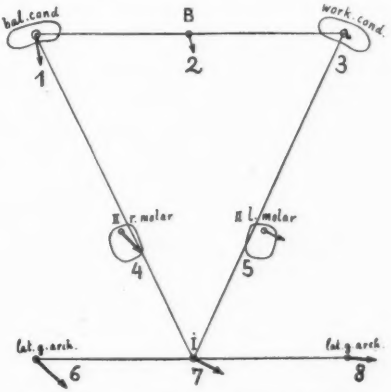


Fig. 4.—Moving body in Figure 1 laid over Fig. 4. When the corners 6 and 8 of the moving body are moved along the arrows 6 and 8, the other movements, 1, 2, 3, 4, 5 and 7, can be determined. In this manner, from any two known movements, the other yet unknown movements can be found. The line, 6, 7, 8, represents the author's facebow, on which the left and right lateral gothic arches are registered. If, in this way, the directions of these lateral gothic arches are known, the lateral movements of any point of the mandible can be determined, and the articulator can be adjusted to these movements. In Figures 2-12, the movements are only two-dimensional gothic arch movements, but in the articulator they will be three-dimensional "arcuate" movements, not only in Hall's articulator but also in the trubyte articulator.

adjustable lateral condyle path (Bennett) (United States of America, patent application filed May 23, 1911, Patent No. 1,041,270, granted Oct. 15, 1912; see also *L'Odontologie,* Paris, 1914, report on a lecture given before La Société d'Odontologie de Paris, Dec. 2, 1913; see also Fig. 134 in "Prosthetic Articulation," edited 1914 by the Dentists' Supply Company, and Figs. 23, 25, 27, in the above-named Swiss dental magazine, 1915). This is exactly the same mechanical device as on Hall's 1917 articulator. Dr. Hall is therefore in error when he

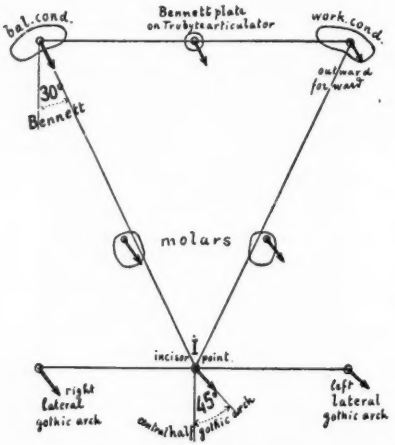


Fig. 5.—Two extreme rare movements of the Bennett and the gothic arch, respectively. If one-half of the central gothic arch (45 degrees) and the balancing Bennett movements (30 degrees) are known, the movement of the working condyle can be determined with much greater precision than by a plaster checkbite.

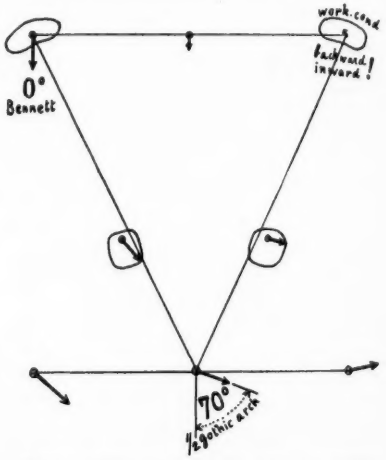


Fig. 6.—Another rare or extreme movement, a 70 degree half gothic arch and 30 degree Bennett movement. The working condyle is bound to move outward. It needs no special checking.

states, on page 19, second column, that "Gysi has now adopted and is using in his work in Switzerland an articulator that is an exact copy in principle of the Hall adjustable articulator." According to these dates and facts I could say that *Dr. Hall copied my articulator,* but I prefer to say only that both of us independently of each other within the space of six years found the same construction, I in the years 1911 and 1914, and Hall in 1917.

Of course, Dr. Hall can be excused for his unfriendly attitude because, during the War, he had no access to European literature, but he could have had a knowledge of the publication through the Dentists' Supply Company and the *Dental Cosmos.* If I were to be as aggressive in my statements as Hall, I could say also that Figure 44 of Hall's paper in THE JOURNAL, July, 1929, was taken from me because this Figure 44, which is credited by Hall to Bonwill, is in fact a combination of my Figures 67 and 73 from the book, "Prosthetic Articulation," published by the Dentists' Supply Company in 1914. Further, the inset figure in Hall's Figure 46 (THE JOURNAL, July, 1929), is an exact copy of my Figure 23

from the *Dental Cosmos* of January, 1910. I leave it to the readers to form their own judgment about all these misrepresentations.

IMPORTANCE OF THE WORKING CONDYLE

Dr. Hall writes in THE JOURNAL, January, 1930, page 42, second column: "For years, I have pointed out the shortcomings of articulators, particularly with regard to the movements of the mandible on the working side. The relations and movements of the working condyle have been far from accurately reproduced. And, to liken the mandible to the three points of the triangle (Bonwill), the movements of the working condyle are at least one-third, if not more, of the story in importance. They are more closely related to the working part of the masticating apparatus. Therefore, it is seen that only two-thirds of the story has been told or accounted for in articulators."

On the same page, he writes further: "Such positional relations and movements are relations and movements in three dimensions and require in turn three-dimensional guidance with which to reproduce them."

On page 48, first column, he writes: "I consider the movement of the condyle on the working side the most important movement."

On page 50, second column: "The new 'trubyte' articulator, which carries Gysi's name and endorsement, is incapable of recording these relations. . . .

"If we are to have complete adaptability in an articulator, we must record and reproduce the relations of the condyle and mandible on the working side. The three-dimensional articulator (Hall's)

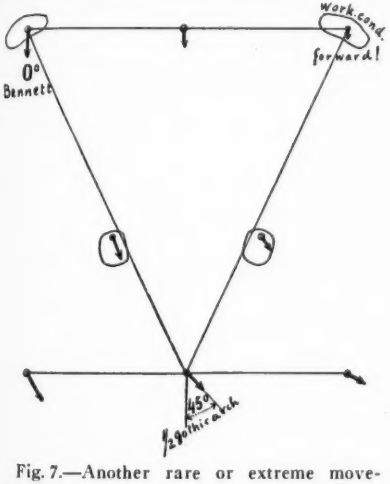


Fig. 7.—Another rare or extreme movement, 45 degree half gothic arch and no Bennett movement. The working condyle is bound to move forward. It needs no special checking.

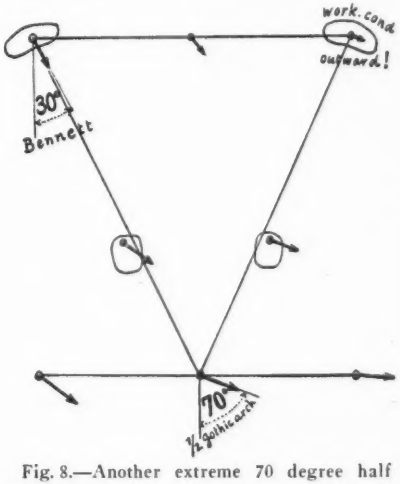


Fig. 8.—Another extreme 70 degree half gothic arch and no Bennett movement. Only in this extremely rare combination is the working condyle forced to move a trifle backward. This working condyle movement is so small because it is very near the side-bite axis and therefore can hardly be checked by any checkbite method.

absolutely and perfectly records the relations of the condyle and mandible on the working side."

These are only a few of a great number of similar statements from Dr. Hall's paper, but these may serve as a basis for my reply.

In order to make a long story short and also more easily understood by the average dentist, I shall refrain from geometric proofs and make use only of movable models similar to the movable cardboard models which I demonstrated in the United States in 1928. Of course, one could say that these models are only two-dimensional and cannot prove the three-dimensional movement. But if we give to the pages of this journal an average inclination of about 30 degrees to the table, we get also three-dimensional movements, forward, downward and inward. I am also aware that Dr. Hall will say that this gives only a two-dimensional gothic arch movement and not an "arcuate" movement, but this remark will be refuted in the fourth part of this paper. So I will demonstrate to those who have no red cloth before their eyes what I have to say about the movements of the working condyle.

We cut from a sheet of thin metal about 0.5 mm. in thickness and about 4 inches square a piece like Figure 1. At the white dots, small pin holes are made in order to locate the last two molars. Then we place this figure on a piece of white cardboard and locate with a needle the six corners on its circumference and the four molar points. After this, we move the metal piece laterally to the right and a little forward (Fig. 2) and mark again with the needle the ten above-mentioned points. If we unite two corresponding needle points with a lead-pencil, we get the movements which these ten points have made. In Figure 2, I have given names to these ten tracings. If we erect on each one of these

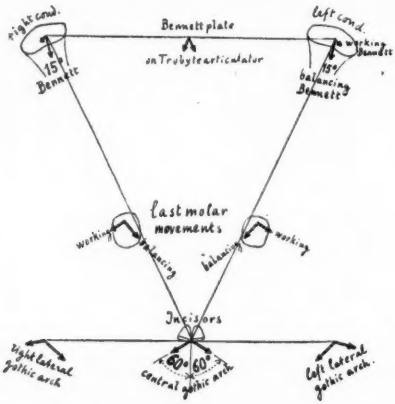


Fig. 9.—An example of a normal or average combination, a 60 degree half gothic arch and a 15 degree Bennett movement, as it occurs most often. Here also the working condyle moves forward and outward and *not backward,* as Dr. Hall considers to be a normal working condyle movement.

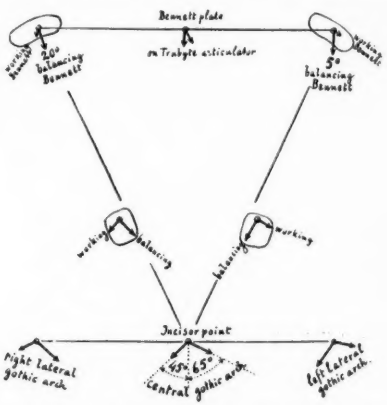


Fig. 10.—A strongly abnormal and strongly asymmetrical combination. Here also, the working condyle does not move backward as Dr. Hall believes.

ten tracings a perpendicular line, these lines meet in a common center (Fig. 3), which is the place where the left side-bite axis pierces the plane which is laid over the condyles and the lower central incisors. (This plane is called the Balkwill plane, in which the Bonwill triangle is situated.)

As I described at length in my latest publication in Scheff's "Handbook of Dentistry" (Prosthetic Volume IV), edited by Urban and Schwarzenberg, Berlin and Vienna, 1929, I measure the gothic arch not only at the incisor point but also to the left and right of it, for all scientific purposes. I told this to Dr. Sears of New York in 1928 when I explained to him my geometric constructions based on these double gothic arches, and he has succeeded in constructing a handy and good working "duplex tracer" which serves the same purpose.

Now we take Figure 4 and on it place the metal sheet in Figure 1 so that all

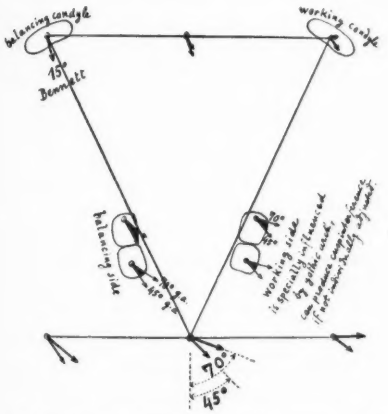


Fig. 11.—Extremes of lateral movements (shown by black triangles on the molars) in different patients when the half gothic arches of the patients are either 45 or 70 degrees, in combination with an average Bennett movement of 15 degrees. This shows the great importance of registering the individual gothic arch of patients. If, for example, the artificial teeth are milled in with carborundum in an articulator having a 45 degree half gothic arch, whereas, the patient has a 70 degree, cusp interference is sure to occur. For this reason, Hanau has to use his complicated correction technic, because he cannot adjust individual gothic arches on his Model H articulator. By adjusting the individual gothic arch on the trubyte articulator, the individual movements of the artificial teeth are guaranteed.

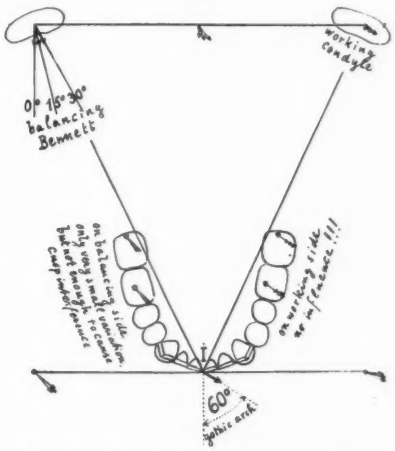


Fig. 12.—Drawing showing that if the gothic arch is not adjustable on the articulator and is the same for every case, as on the Hanau articulator Model H, and if only the balancing Bennett movement can be varied as on the Hanau articulator, a Bennett variation from 0 to 30 degrees gives no variation at all on the molars of the working side and only a very small field of variation on the molars of the balancing side. If, for example, the teeth are milled in on the articulator with an average Bennett movement of 15 degrees and the patient has either a 0 or 30 degree movement (± 15 degrees), then the error on the balancing molars is only half as large as shown in this figure; in other words, it is imperceptibly small for the patient. This is another proof that the checking and adjusting of the lateral condyle movements have not the importance which Dr. Hall believes.

six outer points coincide; cover with a piece of paper the three upper points, 1, 2, 3, and move the three lower points along the lateral gothic arches 6 and 8 to the ends of the arrows. If we do this carefully and then remove the covering paper, the points 1 and 3 have exactly followed the balancing and working condyle movements. So, if we know from a moving body the path of two widely distant points, we can determine the movements of the other points of this body. (The line 6, 7, 8 represents the facebow on which I measure the gothic arches.) If we know the movements of points 7 and 1 (the central gothic arch and the balancing condyle path), we can determine exactly the path of the working condyle in this plane. The working condyle can go in no other direction in this plane; it can go only more or less above or below this plane. But in nature, the working condyle is bound to follow the eminentia articularis, which path can be easily determined by the Stansbery plaster checkbite or my extraoral facebow tracing during a balancing or protrusive movement. In Figure 3, it is possible to make this experiment in twenty-eight variations, always using two known movements in order to find the unknown movements of the other six points.

After these introductory remarks, let us make a practical experiment. Let us assume that we have determined, with my facebow method or with the Sears duplex tracer, one-half of the left and right lateral gothic arches (Fig. 5). Now, we place the sheet metal of Figure 1 on Figure 5. This sheet metal takes the place of an adjustable articulator, and we move it exactly along these lateral gothic arches and mark with a needle the six other points. Then we see that the central gothic arch has made a movement of 45 degrees and the balancing condyle 30 degrees, and that the working condyle has moved outward and forward, etc.

Dr. Hall says that the gothic arch does not guide the mandibular movement, that it is not the cause of the movement but the result of the movements of the condyles. This is perfectly true. But, on the other hand, it is also true that such a movement is a reversible process. We can determine by the resultant movement (the gothic arches) the cause of the movement. In other words, we can reconstruct the movements of the condyles which have caused the gothic arches. The gothic arches are easily accessible, whereas the lateral condyle paths are inaccessible for a direct measurement, therefore I determine the condyle movements indirectly, as the Stansbery plaster checkbites or any other intraoral method also does.

With Figures 6-10, we will determine the movement of the working condyle by two other known movements. For this purpose, we could take the two lateral gothic arches or the central gothic arch and the balancing condyle (Bennett). For this instructive experiment, I prefer the two latter movements, because from my extensive statistics I know those movements which occur most often in edentulous patients.

For half the central gothic arch, these statistics give me as extreme movements 45 and 70 degrees and for the balancing Bennett, 0 and 30 degrees. Movements which are greater or smaller in angle are extremely rare.

As in Figure 6, a patient could have a 70 degree half gothic arch and a 30 degree Bennett movement. These movements we draw on a Bonwill triangle, place the metal sheet of Figure 1 over it and move it with its corresponding

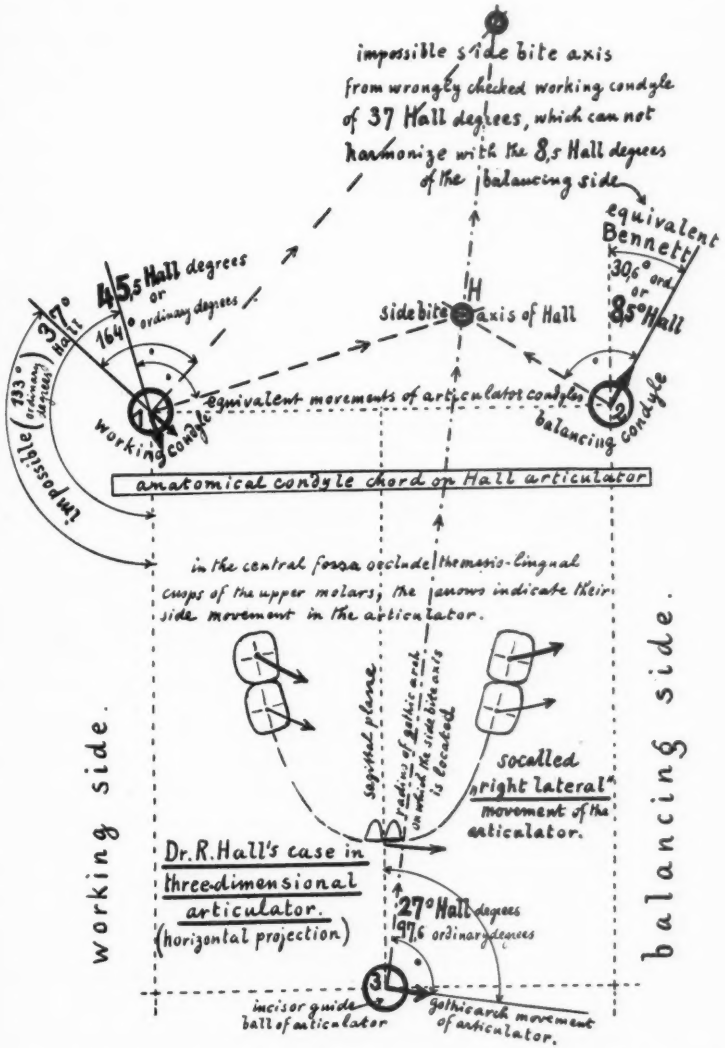


Fig. 13.—Diagram showing why Dr. Hall cannot adjust his own case on his three-dimensional articulator. The working condyle movement of 37 degrees is utterly impossible if the balancing movement is 30.6 degrees. Only if the working condyle guide of his articulator is set at 45.5 degrees (or 43.5 degrees with vertical inclinations adjusted) does the articulator move properly.

points along these two angles. Then we see that the working condyle is bound to move outward as shown in this figure.

In Figure 7, with a 45 degree half gothic arch and a 0 degree Bennett, the working condyle moves directly forward.

In Figure 8, with a 70 degree half gothic arch and a 0 degree Bennett, the working condyle moves backward and a little inward, but so little that it would hardly be possible to check this small movement by a Stansbery plaster checkbite, because this plaster checkbite is located between the molars, which are too near the working condyle, and the movement in this relatively narrow space is very small and at an unfavorable angle toward the working condyle. Only two widely distant points giving a long movement can be used to check the movement of the working condyle that is as near the rotation axis as in this case!

In Figure 9, we have a normal symmetrical or average case with half gothic arch 60 degrees and Bennett 15 degrees. Also, here the movement of the working condyle is very short and cannot be checked by the Stansbery method in the molar space with any degree of exactness.

Figure 10 represents an abnormal asymmetrical case. One half of the gothic arch has 60 degrees and the other half, 45 degrees; one balancing Bennett has 5 degrees and the other, 20 degrees.

If we compare Figures 5 to 10, giving extremes, we see that only in the case in Figure 8 does the working condyle go backward, and only in this case can it leave (for about 20 degrees) the plane in which the balancing and protruding movements take place. It can go only below this plane but not above it, because it cannot penetrate the eminentia articularis and not compress the meniscus more than 0.01 mm. Therefore, if I should have a patient with these very rare extremes (very wide gothic arch and no Bennett), I should reduce the condyle path of the working condyle on the articulator about 20 degrees during the milling in of the teeth with carborundum powder.

In my long practice of forty years, I have had only two patients with such abnormally wide gothic arches, so that, on the average, I should have to practice about twenty years longer to get the chance to try such a case in the trubyte articulator. I should not be afraid if I got a small error on the working side of the finished denture, because I should simply locate the error with articulating paper and correct it by spot-grinding. In all other cases illustrated in Figures 5, 6, 7, 9, 10 and the very numerous intermediary cases, this would not be necessary. Just before writing this, I made the following experiment. I milled in with carborundum a full normal case corresponding to Figure 9 and having a 30 degree downward condyle path to produce rather large facets on the teeth. When I moved this case in lateral occlusion, I could change the working condyle path from 30 down to 0 degrees and up to 60 degrees without interfering in the least degree with the working movement. Any error could have been easily detected on the broad facets of this case.

Therefore, I believe that Dr. Hall is fighting ghosts with his theory of the working condyle, or may I ask him if, after vulcanization, he never has to spot-grind artificial teeth which have been articulated in his three-dimensional articulator? Are not the errors produced by the purely technical processes (impression, casting, bite-taking, waxing and vulcanizing) much greater than the errors which he can avoid by his three-dimensional articulator?

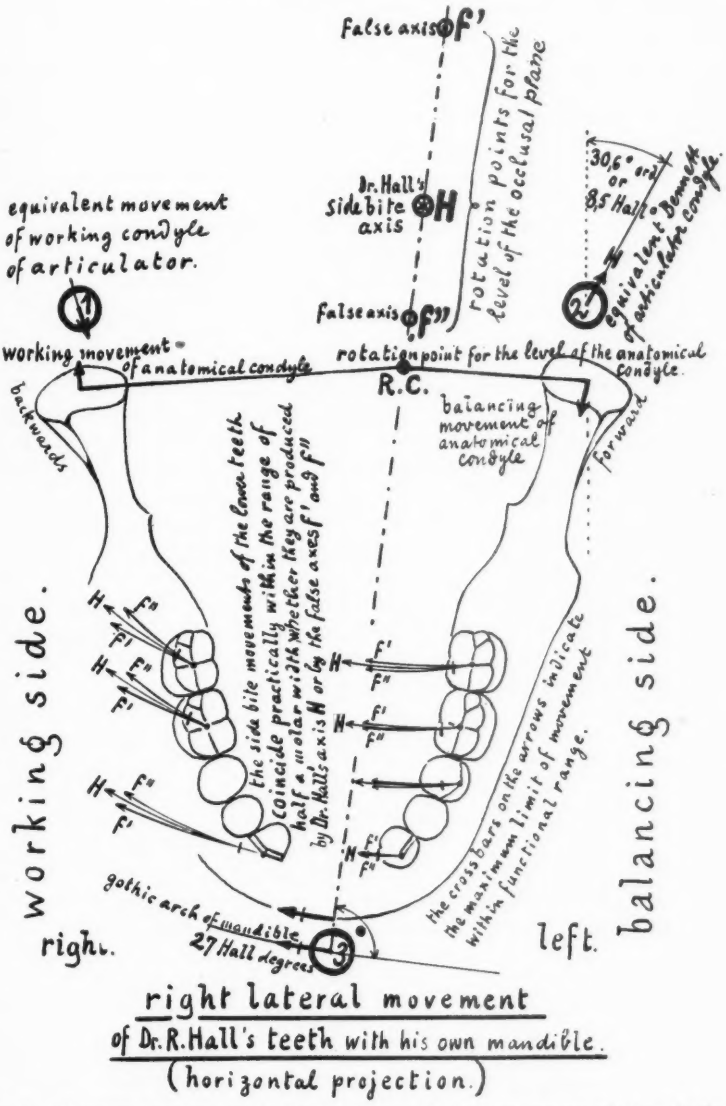

False axis F'
Dr. Hall's side bite axis H
False axis F''
rotation points for the level of the occlusal plane
equivalent movement of working condyle of articulator.
30,6° or 27 Hall°
8,5 Hall°
equivalent Bennett of articulator condyle
working movement of anatomical condyle
rotation point for the level of the anatomical condyle
R.C.
balancing movement of anatomical condyle
backwards
forward
the side bite movements of the lower teeth coincide practically within the range of half a molar width whether they are produced by Dr. Hall's axis H or by the false axes F' and F''
working side.
balancing side.
the crossbars on the arrows indicate the maximum limit of movement within functional range.
gothic arch of mandible
27 Hall degrees
right.
left.
right lateral movement
of Dr. R. Hall's teeth with his own mandible.
(horizontal projection.)

Fig. 14.—Diagram showing that in Dr. Hall's case, it does not matter whether the lateral condyle movements are set accurately so as to establish his individual axis *H*, or the articulator corresponding to his mandible moves around the false axes *F'* or *F''*. In all these cases, the movements of the teeth coincide within the functional range. Why take the great trouble to check the lateral condyle movements? The individual vertical condyle path, the individual lateral incisor path (gothic arch) and an average balancing Bennett of 15 degrees are all that are needed for a good set of artificial teeth.

Dr. Hall writes in his article, page 47, second column: "I should like here to point out that the movement of the incisor point is a resultant of mandibular movement and not a cause or directing factor in its movements. Therefore, reproduction of the movement of this point is of no greater importance than that of any other point and it does not follow that correct reproduction of the movement of this point insures correct movement of the other points. There is no scientific justification whatsoever for Gysi emphasizing the movement of this point as he does."

Well, then, the readers of this paper can judge this for themselves if they are willing to make the experiments illustrated in Figures 11 and 12. In Figure 11, we have a Bennett movement of 15 degrees. If we combine with this Bennett movement the two extreme half gothic arches of 45 and 70 degrees, a broad field of variation on the molars of the balancing and working sides is the result, so that if the gothic arch is not individually adjusted on the articulator, cusp interference will result if the gothic arch of the patient differs much from the gothic arch of the articulator. It is clearly to be seen also that the movement of the working condyle differs as soon as the gothic arch differs, because the gothic arch is partly produced by the movement of the working condyle, as Dr. Hall has rightly found out! This experiment therefore clearly shows that by the adjusting of the gothic arch on the articulator, the working condyle is automatically adjusted or directed on the articulator. The trubyte articulator is built especially to give the proper movement of the working condyle without special registration, simply by adjusting the gothic arch. With the Hanau articulator (Model H), this cannot be done, because the condyle axis on the working side rests against a stop which always allows in every case only the same outward movement, but never forward in the least degree.

With Figure 12, we can make the reverse experiment. Here, we can give to the balancing condyle three different movements of 0, 15 and 30 degrees Bennett, while the gothic arch remains the same in all three cases. The result is that, on the molars of the working side, no field of variation is produced, and on the last molars of the balancing side, only a very small field of variation is produced, not large enough to cause cusp interference, if the Bennett movement of the patient differs from the Bennett movement of the articulator.

This small field of variation would be produced if the Bennett movement of the patient differed 30 degrees from the Bennett movement of the articulator, a case that I have never met. But if the trubyte articulator is set at an average Bennett movement of 15 degrees, patients could differ from it only 15 degrees Bennett, and this difference would then produce a field of variation on the balancing molars only half as large as that shown in Figure 12, a small error which could not be felt by the patient.

To close this chapter, I must correct a criticism by Hall by saying that my gothic arch registration was designed to find centric relation of the mandible in edentulous cases and to guide the lateral movements of the artificial teeth. I have never advised the use of the gothic arch tracing when antagonizing natural teeth are present in more or less number in both jaws. It can, however, be used in such cases also, but then the registering plate should not be fixed on the occlusal surfaces of the natural teeth but on their buccal surfaces by means of the "Köhler attachment," which is described and illustrated

in my chapter on "Articulation" in the "Handbook of Dentistry," Vol. III, edited by Christian Bruhn, printed by J. F. Bergmann, Munich, 1929 (see pages 258-259). (For this publication, I received the Swiss Marcel Benoit Prize of 30,000 francs ($6,000). I only mention this in order to show Dr. Hall that I receive prizes in Europe also.)

DR. HALL'S CHALLENGE ON HIS OWN CASE

On page 43, second column, Dr. Hall writes in the January number of THE JOURNAL: "I should like to see, and I here challenge him (Gysi), or any one

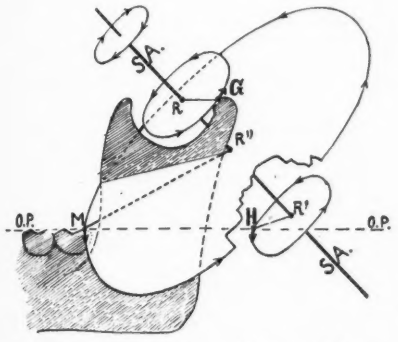


Fig. 15.—*G*, anatomic working condyle; *H*, the equivalent condyle guide of Hall's three-dimensional articulator. *S. A.*, an example of how the side-bite axis can have a position and an inclination. The arrows indicate a working-side movement around this axis. It is evident that during a lateral movement (rotation), the equivalent working condyle *H* on Hall's articulator would make just the contrary movement to the anatomic condyle *G* of his mandible. For this reason, the dial readings of Hall's articulator cannot be compared directly with the dial readings of the trubyte articulator whose condyle part is above the occlusal plane (*O. P.*) as in nature.

of his followers, to check or record Stansbery's three-dimensional registrations of edentulous cases or bites of my own mandibular relations with his latest instrument, the 'trubyte' articulator, or, for that matter, with any of his articulators with which we are familiar."

If we study Figures 5-9, representing the extremes of mandibular lateral movements which rarely occur in our daily practice, we see that the working condyle goes backward only in the extremely rare case in Figure 9. Even if the face-bow registration of a lateral movement of the working condyle seems to show a backward movement, it is generally due to a wrong projection, as I proved in the "Handbook of Dentistry," Vol. III, edited by Dr. Bruhn, Munich, 1926, in Figures 171-173, or in the second edition of the same "Handbook," 1929, in Figures 18-20, and further in Scheff's

Fig. 16.—Natural condyles, having two facets, which form an angle.

"Handbook of Dentistry," Vol. IV, 1929, edited by Hans Pichler, Vienna, in Figure 43.

Dr. Hall has a different opinion about *the normal movement of the working condyle*. He writes in THE JOURNAL, page 20, second column: "The typical lateral movement of the mandible (ideal normal, apparently) shows that the condyle on the balancing side moves forward, downward and inward and the *condyle on the working side moves backward,* upward and outward (Figures 11 and 12 in previous article)." (The "previous article" referred to was published in THE JOURNAL, July, 1929.)

I sincerely believe that in Dr. Hall's mouth, his natural teeth force the man-

dible to make this movement and force the working condyle to go backward. If we inspect his Figures 11 and 12, representing his case, in the July, 1929, number of THE JOURNAL, and compare the dial readings which belong to this movement in Figure 1, we see not only that the central gothic arch is very flat, but that it is even more than straight, 27 Hall degrees, which is 7 degrees negative on each side, giving 194 ordinary degrees for the whole arch. This is really something extraordinary. It means that during a lateral movement, the incisors do not move forward in the least but go 7 degrees backward! This cannot be regarded as normal, not even as abnormal; this is erratic!

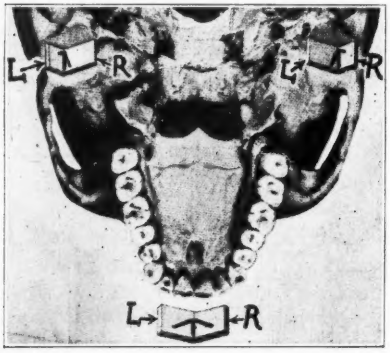


Fig. 17.—Glenoid cavity, having two facets with a groove between them. The gothic arch movement is in nature (when natural teeth are present) a two-surface movement. For this reason, the protrusive movement in the groove between the two surfaces is a trifle (from 5 to 10 degrees) less inclined than the lateral movements on the two surfaces forming the groove. *L*, left lateral movement; *R*, right lateral movement. (After Fischer.)

It has often occurred in the history of research about mandibular movements that an investigator has experimented with his own mandible and then has published his findings in which he has declared that these are the *normal* mandibular movements, because he believed himself to be approximately normal in every respect. I think that Dr. Hall wants to challenge me on his *extremely abnormal case.*

Such a movement my articulator could reproduce only when the incisor guide plate is used unilaterally by removing both fixing screws. I have never come across a case which I could not reproduce with my adjustable articulators. But if

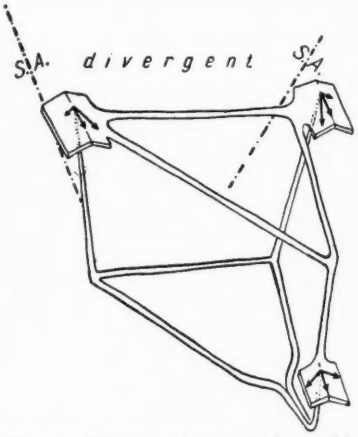


Fig. 18.—Diagram of an articulator with a two-surface guidance, which Dr. Hall calls an "arcuate" guidance.

more than a thousand such abnormal men as Dr. Hall are living on earth, so that every hundredth dentist runs the risk of coming across such a patient once, it will be necessary to furnish with the trubyte articulator, besides the regular positive incisor guide plate, a negative plate also.

Dr. Hall's case is so difficult to check and to adjust on his three-dimensional articulator that *not even Dr. Hall can do it properly.* I made a very thorough

analysis of his case, according to the articulator readings which he gives in Figure 1 of the July, 1929, number of THE JOURNAL. I set the Hall three-dimensional articulator that I possess very carefully to these readings, but during the left lateral and right lateral movements, the working condyle part did not follow the deepest part of its groove and moved upward along its side walls! For example, the right condyle of the articulator did not follow along a path of 37 Hall degrees during a right lateral movement when it had to function as the working condyle. Only when it was set at 43.5 Hall degrees did proper function take place. A similar error exists during a left lateral movement also. Here, the working condyle follows another path than the table in Figure 1 indicates!

Then I located in Figures 11 and 12 of the same JOURNAL the rest positions of the three legs of the upper articulator part and drew a line through the center of the grooves. After this, I cut from heavy paper a triangle whose three corners correspond exactly to the three rest position points, and I tried to move this triangle along the center line in the grooves; but here also there was a great discrepancy on the side of the working condyle. Therefore, those two photographs in Figures 11 and 12 are wrong, because the articulator of which these photographs were taken was set wrong.

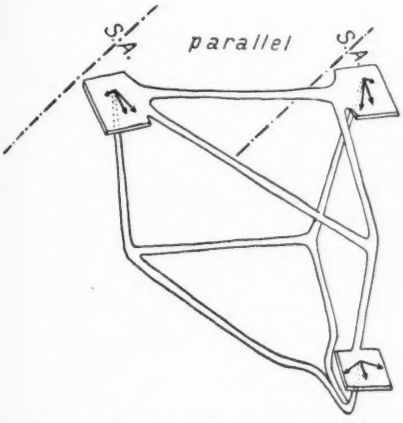


Fig. 19.—Diagram of an articulator with a "one-surface" guidance. This arrangement is cheaper and easier to adjust and to handle than the "two-surface" or "arcuate" arrangement in Figure 18. Also, the artificial teeth made with such a one-surface guidance articulator (trubyte articulator) are less likely to tilt and shift in the mouth, as proved with author's movable cardboard models in 1928.

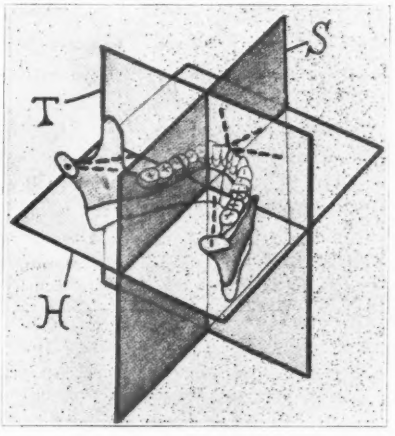


Fig. 20.—Mandible between the planes of orientation. *H*, horizontal or occlusal plane; *S*, sagittal plane; *T*, transversal or frontal plane. The dotted lines show the condyle movements and the gothic arch movements which do not coincide with either one of these planes and are therefore three-dimensional movements in the trubyte articulator as well as in the "three-dimensional" articulator of Dr. Hall. The trubyte articulator also is a three-dimensional articulator, because the occlusal plane and the cusps of the teeth form a certain angle with the three planes of orientation. (After Fischer.)

Any one who has a Hall three-dimensional articulator can confirm these findings of mine, but only on condition that the three horizontal dials of the articulator are properly centered. In the instrument which I possess, this was not the case, because they are so easily movable that the lines 0-50 degrees of the three dials were not originally parallel to one another. I first had to make them parallel and to fix them with soft tin solder before I could get reliable results.

As a result of this experiment, may I ask: *Why does Dr. Hall want to challenge me on his own case when he himself is not able to adjust his own articulator according to several series of checkbites?*

In order to be quite sure about these findings, I made the geometric test about this case as shown in my Figure 13. I first located on a piece of paper the positions of the centers of the three balls on Hall's articulator (upper part) (Fig. 13—the three circles, 1, 2, 3). These three centers were surrounded by a rectangle, forming the ordinates from which the angles of the respective movements could be determined (Fig. 13—dotted lines). Then the degrees of the movements of a right lateral bite, according to Hall's Figure 1 in the July, 1929, number of THE JOURNAL, were determined, 37 Hall degrees for the working condyle, 8.5 Hall degrees for the balancing condyle, 27 Hall degrees for the incisor guide (gothic arch). On these three movements, radii or right angles were erected (as described in my Figure 3), in order to find the side-bite axis where these three right angles intersect. The side-bite axis in every case is situated somewhere on the radius coming from the gothic arch. The radius from the balancing condyle intersected the gothic arch radius at point *H* and the radius from the working condyle very much farther back. This is another proof that there is something wrong about the degrees of the movement of the articulator condyles. After drawing a line from axis *H* to the working condyle 1, and drawing a right angle to it, I found 45.5 Hall degrees for this working condyle movement, instead of 37 degrees, as Hall indicates. After this, I set the three guides on the Hall articulator without vertical inclinations to the condyle dial reading 45.5, 8.5 and 27 degrees for the gothic arch guide, as shown in my Figure 13, and found that all three guide balls moved in the deepest part of the guide grooves! This was a proof that my geometric construction of Figure 13 is right! Only when the vertical inclinations of the balancing guide (11.5 degrees) and the gothic arch guide (9.5 degrees) were adjusted did the working guide need a horizontal reading of 43.5 instead of 45.5 degrees. With these adjustments, the movements of the articulator were true!

Figure 13 also shows the monstrosity of Dr. Hall's case. In all cases that I have met during my long practice, the side-bite axis *H* has always been in the neighborhood of the working condyle; whereas, here, it is in the neighborhood of the balancing condyle!

Using Figure 13, I made another investigation (Fig. 14). The three main points, 1, 2, 3, were transferred to another paper and the anatomic condyles located on the condyle chord of Hall's articulator; also, the positions of the teeth were located from Hall's photograph of his Figure 11 in their proper distance from the anatomic condyles.

Then, one point of a divider was set at the location of Dr. Hall's side-bite axis *H*, and, with the other point, circles toward the working side were drawn

from the central fossae of the molars and the cusps of the cuspids. These circles imitated a right lateral movement of Dr. Hall's mandible. Now, I arbitrarily located on the radius of the gothic arch two other centers, *F'* and *F''*, far away from Dr. Hall's individual center *H*. These two false centers produce working condyle and balancing condyle movements that differ from Hall's movements from 40 to 70 ordinary degrees! !

If circles are drawn from the same central fossae of the molars as before, but with the false axes *F'* and *F''* as centers, one can easily see that these false circles *F'* and *F''* practically coincide with the true circles from the axis *H*. This coincidence occurs only within the range of half a molar width, which represents the functional range of a side-bite movement or lateral occlusion. At any rate, it makes no perceptible difference whether the teeth move around the true center *H* or the false centers *F'* and *F''*. Of course, a mathematical difference exists, but not a practical one.

This coincidence I found several years ago, and it led me to the conclusion that the great trouble taken to determine the individual movements of the balancing and working condyles does not pay, and that we can average these movements with perfect safety if we have checked the individual gothic arch, because it is by means of the latter movement that we can check the lateral occlusion of the teeth. On the ground of this averaging, Dr. Hall declares that I am "inconsistent" with my former writings in which I said that "every mandibular movement should be individually checked." Of course, this would still be the ideal or 100 per cent, but how many in America have followed this ideal of mine? The vast majority have not done so, and those who have could not reach the goal because the checkbite methods with plastic materials (wax or compound) are not reliable!

As Dr. Hall writes in the July, 1929, number of THE JOURNAL, page 1167, first column: "One man prominent in the work made the statement to me: 'These things (adjustable articulators, etc.) are fine and I believe in them, but I have to get the work out and get the money. My patients will not pay the fee to justify their use and I have not the time to bother with them'." This same statement I have often heard from average men and also from prominent men, and therefore I decided that, in order to prevent every kind of mandibular registration being thrown away, it would be better to tell dentists that they can very well ignore the registrations of the lateral condyle movement if they register at least the gothic arch movement and the protrusive condyle movement, which can be done very easily with my facebow method. This is no "retrogression"; this is a practical conclusion from my latest research work.

Dr. Hall writes also in THE JOURNAL, January, 1930, page 45, second column: "That I have changed my mind and retracted certain of my former claims is no disgrace to me or to any one." If an inconsistency is no disgrace to Hall, I cannot see the reason why I should strictly adhere to every detail that I taught twenty years ago in my first publication. When I produced my simplex average articulator, I knew that only a very small percentage of dentists would take up my individual registration method, and that therefore I could help dentistry at large by using the simplex articulator to get away from the plane-line or hinge-joint articulator. Is this a disgrace also? Hanau thinks so!

In Figure 14, I have marked on the gothic arch radius another rotation point

(*R.C.*). This is the rotation point for the lateral movements of the condyles. The center *H* is true only for the movements which take place on the level of the occlusal plane (the teeth) and for the condyle guides of Hall's three-dimensional articulator, because they are approximately on this level also. But the anatomic or natural condyles of Dr. Hall are on a higher level, which is about 30 mm. above the occlusal plane. So, in order to gain knowledge about Dr. Hall's anatomic Bennett movement, I had first to find this center (*R.C.*). I made the construction in a way similar to those described in my new book (Scheff, Vol. IV). As I cannot here repeat most of the contents of this book, I merely fixed this center *R.C.* in my present Figure 14.

From Figure 15, one can get a slight idea that when the center *H* on the level of the occlusal plane is relatively far behind the condyles, the centers at the level of the condyles are farther forward, because the side-bite axis, being about at right angles to the vertical condyle path (in Dr. Hall's case 41 degrees), is strongly inclined from behind forward. If one point of a divider is set at the center *R.C.*, with the other divider point the balancing Bennett and the working Bennett movements of the condyles can be drawn, and these *anatomic* Bennett movements have only about 10 ordinary degrees, which can be very well adjusted on the trubyte articulator! Only the *equivalent* Bennett movement of Dr. Hall's case on the balancing side during a left lateral bite cannot fully be adjusted on the trubyte articulator, because it amounts to about 41 ordinary degrees.

This also shows that the dial readings of the Hall articulator cannot be compared directly with those of the trubyte articulator. In my Figure 14, one can see that the equivalent balancing movement of Hall's articulator is 30.6 ordinary degrees; whereas, the anatomic balancing movement of the trubyte articulator would be about 7 ordinary degrees.

Another peculiarity of Dr. Hall's own case lies in the fact that the working condyle movement takes place horizontally backward. But the backward movement can easily be managed on the trubyte articulator also, because there is special clearance provided for this movement by removing the roller bearing; and horizontally, it can also take place. It would only be necessary to set the vertical inclination of the working condyle path at 0 degrees during the time when the teeth are milled in with carborundum for a right lateral movement. To summarize this investigation, let me say that the trubyte articulator could be adjusted exactly to Dr. Hall's own very abnormal case! If he cannot do it, I can do it, because I know how to use it; whereas, Dr. Hall has not been able to check his own case on his own articulator.

When the Dentists' Supply Company was preparing to manufacture my trubyte articulator, they asked my opinion of Phillips' articulator in comparison with my own. I told them that I considered my articulator to be only 98 per cent perfect, but thoroughly practical and relatively easy to handle; whereas, the Phillips instrument I consider to be 100 per cent perfect but difficult to handle. After this, the Dentists' Supply Company determined to manufacture both articulators. Today, I could say the same thing in comparing my 98 per cent trubyte articulator and Hall's three-dimensional 100 per cent articulator, which I consider to be superior, from a purely theoretical standpoint, for complicated cases in which irregularities in the position of natural

teeth are present. However, only for these cases is it 100 per cent perfect, yet very difficult to handle! For this reason, I do not seriously consider Dr. Hall's challenge, but leave it to the dentists to use any articulator they prefer. If any one is willing to go through the same troubles as Hall describes on page 49, second column, then he may use Hall's three-dimensional articulator in order to be 100 per cent sure. Hall writes on this page: "The case was checked by Stansbery himself in my office, after which I spent ten days verifying his findings with several series of like bites made by myself and further with the central bearing test . . ."

An articulator is regarded as an instrument which permits one to do certain steps of prosthetic work out of the mouth in order to save time for patient and dentist. But in such abnormal cases, and only such, could time be saved by doing the work directly in the mouth with the natural articulator of the patient!

I do not find it necessary to accept the challenge to check or record edentulous cases which have been registered by Stansbery plaster checkbites, because the trubyte articulator is not built to respond easily enough to plaster check-bites. The trubyte articulator is built especially for the facebow technic, and I have no reason for working "without the facebow" by taking during an hour an average of about nine plaster bites, if, in one-fourth the time, the facebow registrations are possible. I do not strive after 100 per cent perfect technic. I and a very large number of dentists and their patients are perfectly satisfied with 98 per cent "trubyte" technic. This is similar to the technic for getting pure aluminum. The ordinary industrial aluminum is only about 98 per cent pure, and to get rid of only 1 per cent of the impurities more than doubles its price; for to eliminate the last trace is so difficult, time-consuming and costly that it pays to use aluminum of this purity for a very few special purposes only. So it is with the speed of steamers. In order to get 15 per cent more speed, more than the double amount of fuel is needed.

I willingly let Dr. Hall have for his three-dimensional articulator his theoretical 100 per cent, and I claim for the trubyte articulator only the actual 98 per cent. If I wanted to get 99 per cent, I should register, instead of the central gothic arch, the two lateral gothic arches (see my Figure 3, and my new book, Scheff, Vol. IV, Berlin and Vienna), because then I could surely get the Bennett movement of the balancing condyle and thereby also the working side Bennett movement. The 100 per cent mathematical precision toward which Drs. Hall and Stansbery are striving can be compared with the exact methods for measuring time. A man could say that our watches do not keep time 100 per cent, and that therefore they are no good, and then recommend other means for measuring and keeping time by saying: "The only reliable 100 per cent method is the astronomic method, by reading the time from the sun or the stars, or by the use of a real chronometer." Of course, that is true, but not practical, because the astronomic instruments are very costly, difficult to handle and time-consuming and can be used only when the sun and the stars are visible. Therefore, in ordinary life, it is better to be satisfied with an exactitude of less than 100 per cent. For this same reason, my patients and I are perfectly satisfied with the results of my 98 per cent trubyte articulator!

There is another reason why I do not consider the challenge. Dr. Hall's articu-

lator has its condyle part at the level of the occlusal plane. This he can have with perfect safety because he is working with an equivalent condyle path. My trubyte articulator has its condyle path at the level of the anatomic condyles and is therefore working with the anatomic condyle path.

For this reason, with one and the same checkbites, Hall and I would get different readings on our articulators, readings which could be 180 degrees different, that is, just contrary to each other; whereas, in results on the movement of the teeth, they could be the same. That seems strange on first thought. I will try to explain it.

A full explanation, however, I cannot give here because it would be necessary to make the three-dimensional or solid-geometric constructions which I published last year in Scheff's "Handbook of Prosthetic Dentistry" (Berlin and Vienna), and these are not easily understood by the majority. So I present here only a two-dimensional approximate illustration.

Let us suppose that in Figure 15 we have the working condyle and very close to it the imaginary rotation axis *S. A.* for the side bite. At the level *G* is the anatomic condyle of the Gysi articulator, and vertically below, and 1 cm. behind at the level of the occlusal plane, *O.P.* at point *H* is the equivalent condyle guide of the Hall articulator. *R* and *R'* are the coordinated rotation points on the side-bite axis. Now, it is evident that when a solid body, as, for example, the articulator, rotates around the imaginary axis *S.A.*, point *G* moves upward and backward and point *H* moves upward, outward and forward. Such a position of the side-bite axis very near and inside the working condyle can happen in cases similar to that of Figure 8, where the gothic arch is wide and the Bennett movement is small, and, if at the same time the incisor overbite is about zero, the side-bite axis is strongly converging from behind and outside the mandible upward, forward and inward, so that at the level of the condyle, the axis is already inside the working condyle. If Dr. Hall intends to discuss such relations with me he should first study my two latest publications and the publications of my assistant collaborators at the University of Zurich instead of always criticizing me on the ground of what I published twenty years ago in the *Dental Cosmos.* Dr. Hall cannot know my present views fully, not only because he has had no occasion to see my latest publications but also because I had no occasion during my last visit in the States (1928) to present a full synopsis of my new findings, for the reason that I was officially requested to present a "practical" paper and not to lecture about artificial teeth, articulators or geometric construction illustrating mandibular movements! So that is what I did, in addition to showing a few samples of my large collection of movable cardboard models.

TWO-DIMENSIONAL AND THREE-DIMENSIONAL ARTICULATORS

Dr. Hall writes in THE JOURNAL, January, 1930, page 41, second column: "The Gysi trubyte articulator is a two-dimensional gothic arch articulator and cannot, therefore, reproduce the arcuate movements of the mandible and accurately check three-dimensional positional relations of the mandible," and on page 42, second column: "Such positional relations and movements are relations and movements in three dimensions and require in turn three-dimensional guidance with which to reproduce them."

In THE JOURNAL, July, 1929, page 1174, second column, Dr. Hall writes:

"Because of the inability of the prosthetist to determine and to imitate the precise movements of the patient's mandible between positional relations with articulators and the inaccuracies in general that creep in, it is necessary that the natural moving jaw be utilized in perfecting the occlusion of artificial dentures."

This last sentence covers my opinion also about the present condition of the registration of mandibular movements and the value of articulators reproducing "arcuate" mandibular movements, and for this reason, I built the trubyte articulator as it is. For the dentist of today, and for many years to come, it is quite sufficient if he knows the vertical (sagittal) condyle path and the lateral movement of the incisors (gothic arch) of his patients. If dentures thus made show in the mouth some slight discrepancies between the articulator movements and the individual mandibular movements, it is easy to detect them with articulating paper and correct them by spot-grinding, as Dr. Hall also is forced to do. These discrepancies are caused mostly by "the inaccuracies in general that creep in" during the bite-taking and the rubber shrinkage during vulcanization, and very, very seldom by inaccuracies in the articulator itself.

All the troublesome procedures to check the lateral condyle movements of the working and balancing sides which Dr. Hall advocates in relation to his three-dimensional articulator are nearly always nullified by the inaccuracies of our materials and the purely technical procedures employed in the making of a denture. It is therefore quite sufficient to check only the above-mentioned main movements of the patient's mandible and to average the finer details of them.

I will now analyze these finer details of the so-called "arcuate" movements as my assistant, R. Fischer, described them in his dissertation published in 1926 in *Die Schweizerische Monatsschrift,* Vol. XXXVI, No. 6, the same year that Dr. Hall introduced his three-dimensional arcuate articulator, before we had any knowledge of the existence of this instrument.

Fischer says:

As the condyles have two distinct facets (Fig. 16), so the glenoid fossa has two lateral slopes forming a groove (Fig. 17). During a protrusive movement, the condyles move along the deepest part of this groove. During a lateral movement, the balancing condyle moves along the inner slope and the working condyle along the outer slope (Fig. 17). The effect of this is that the paths of the balancing and working movements are more inclined (sagittally) than the pure protrusive movements of the condyles.

When the natural teeth, especially the incisors, are present, the anterior movements of the mandible at the incisors take place also on a double surface (Fig. 17). During a pure protrusive movement, the movement takes place along the groove formed by these two surfaces, and during the lateral movements, the movements of two branches of the gothic arch take place on the two surfaces forming the groove, and this lateral movement is steeper than the protrusive movement, when viewed from the side or when it is projected on a sagittal plane.

So we can say that the two posterior guides of the mandible (the condyles) and the anterior guide of the mandible (the incisors—on the articulator, the gothic arch incisor guide) produce a protrusive movement of the mandible which is less steep than the lateral movements of these three double-surface guides.

As the incisor guide in all ideally normal natural dentures has a steeper inclination than the two condyle guides, it happens that, during a protrusive movement, only the incisors keep up the contact of the tooth rows; whereas, the bicuspids and molars separate. The effect of this is that the whole masticating force comes into action only at the incisors, because there is no contact at the molars, and so the incisors can be effectually used to cut and tear fibrous food and eventually act as a weapon or tool.

On the other hand, because a lateral bite moves on steeper guide surfaces, the lateral working facets of the molars are steeper than the protrusive facets of the molars. The effect of this is that, during a lateral bite, the incisors come out of contact so that the whole masticating force is thrown on the molars, because the incisors cannot absorb any part of this force, and so the molars can function with their maximum triturating force.

This natural condition Fischer calls a *"double-surface guidance"* of the condyles and incisors, and I suppose that what Dr. Hall calls an "arcuate" movement is in principle the same thing.

Figure 18 herewith, or Figure 114 in my book (Scheff, Vol. IV), illustrates schematically this double-surface guidance.

Now, I could understand it if Dr. Hall should ask me why I did not embody the "double-surface" or "arcuate" principle in my trubyte articulator when I already had a knowledge of this principle in 1926 or even long before. On this question, I can tell Dr. Hall that I did make a double surface articulator for my own purposes for experimentation, and the results of these experiments led me to build and give out only a "one-surface" or "gothic-arch" articulator in the form of the present trubyte articulator. (See Fig. 19, or Fig. 115 in Scheff, Vol. IV.)

The reasons for this procedure are the following:

1. Dentists have to use an articulator for making *artificial* teeth and not for checking natural dentures, as Dr. Hall does with his own natural teeth.

2. Nature can use the double-surface principle, which throws out of contact one or the other series of natural teeth, either for incising or for triturating purposes, because natural dentures do not tilt nor shift, but artificial dentures would do so. Artificial dentures must have balanced occlusion, so that, between meals, when no food is between the teeth, the dentures neither tilt nor shift when the teeth do not close perfectly in central occlusion.

3. What would be the use of a "double-surface" or "arcuate" articulator if the checking of the double surface of the glenoid cavity is so difficult that 999 out of 1,000 dentists would not practice it, even if the price and difficulty of handling such an articulator were no hindrance?

4. I preferred to build an articulator which does not necessitate using molars whose working facets are steeper than the protrusive facets. I prefer working facets of the molars that are not steeper than the protrusive facets in order to avoid the tilting forces on the working facets, as I demonstrated with my movable cardboard models. Therefore, my trubyte teeth and crossbite teeth are not wrong. Of course, I know that thereby an error in the lateral condyle guidance can occur if the lateral condyle path of the patient is about 5 to 10 degrees steeper than the protrusive condyle path. But when this error in the condyle guidance reaches the last molar, it amounts to only about 0.1 mm. On account of this 0.1 mm. error, which may occur in some cases, I say that my "one-surface" articulator is only 98 per cent perfect. If dentists were able to take the "bite" with such exactness that the error was not greater than 0.1 mm.; if the rubber shrank less than 0.1 mm., and if the mucous membrane over the alveolar ridges had a resiliency of less than 0.1 mm., it would be necessary to use an "arcuate" articulator to check the patient's working balancing condyle path! Those who want to avoid this "error" are free to use Hall's "arcuate" articulator, which is theoretically 100 per cent perfect; I will never hinder them from doing so.

But with the trubyte articulator also, this 0.1 mm. error can be avoided if, during the milling in of the artificial teeth with carborundum for lateral movements, dentists set the balancing condyle path 5 degrees steeper and the working condyle path 10 degrees steeper than the vertical or sagittal or protrusive condyle path!

Dr. Hall writes in THE JOURNAL, January, 1930, page 48, second column: "For the same reason that Gysi's articulator is wrong, his teeth (trubyte and crossbite) are wrong, because they are carved in his articulators which move on the principle of two-dimensional gothic arch movement instead of in articulators that move on the three-dimensional arcuate principle."

It is not the first time that one of my articulators has been declared to be wrong. In 1920, eight years after my simplex articulator was on the market, a prominent teacher in America (I will not publicly mention his name, because he is dead now) declared that this articulator was wrong ". . . because it is built on Bonwill's principle of the equilateral triangle, and, as it has been proved by measuring thousands of human mandibles that a mathematically exact equilateral triangle never could be found, this theory of Bonwill has exploded. The science of logic teaches that when the premises are wrong, the deductions from them also are wrong. Therefore Gysi's articulator is wrong!" Since this death-sentence, thousands and thousands of the simplex articulators have been sold in America, because if the plaster models are placed in the articulator by means of the facebow, every irregular Bonwill triangle can be produced!

The last quotation from Dr. Hall is simply words and has no sense at all. In the trubyte articulator, the condyle part can move forward, downward and inward (Fig. 20), that is, in three dimensions, because it moves neither in the sagittal plane (S) nor in the transversal plane (T) nor in the horizontal plane (H), but the condyle moves in the space embracing all three planes. Also, the incisor guide can move backward, upward and sidewise, and this is also in three dimensions, in relation to the customary planes of three-dimensional orientation (Fig. 20, dotted lines). If we laid over a mandible a plane touching the two condyles and the edges of the incisors and placed the occlusal plane of the teeth parallel to this condyle-incisor plane and then made articulating movements in this plane, only then would we have a two-dimensional movement which would not allow cusps on the teeth, and which movements would allow only Hall's inverted cusp teeth to be set up in this occlusal plane. But as soon as the condyle-incisor plane forms an angle of about 20 to 30 degrees with the occlusal plane, teeth with cusps are necessary to guarantee balanced occlusion.

Of course, it is possible for Dr. Hall to give another definition of the conception "three-dimensional" which would not include the movements of the trubyte articulator.

In Scheff's "Handbook," Vol. IV, I described and illustrated an experiment which runs as follows:

I fixed in the trubyte articulator a flat block of plaster horizontally in the occlusal plane and, on this block of plaster, I placed a double row of shark's teeth similar to the teeth of a saw for cutting wood and fixed these saws to the opposite articulator frame.

Now, if all kinds of human masticating movements are made with the articulator, protrusive and lateral to left and

right, and all intermediary movements, the saw teeth carve out from the plaster block the primordial forms of the masticating surfaces of human molars, with cusps and grooves, and cusp facets which are inclined in different directions in the three-dimensional space. I think this is the best proof that the trubyte articulator really makes three-dimensional movements, because it can carve out a three-dimensional solid. If I make the same experiment in my "two-surface" or "arcuate" articulator (Fig. 18), the result does not differ materially. Therefore, all that Dr. Hall writes in THE JOURNAL, January, 1930, about the two-dimensional gothic arch movement of the trubyte articulator and the three-dimensional arcuate movement of his articulator is only throwing sand in the eyes of dentists. This writing of his cannot be called scientific; I leave it to the reader to form his own opinion about it. In my opinion, Dr. Hall is not the man to help the Bureau of Standards to build a standard articulator.

I cannot understand in Dr. Hall's article in THE JOURNAL what all this stressing to check not only the balancing condyle but also the working condyle movements in three dimensions and to use a three-dimensional gothic arch on a three-dimensional articular which gives "arcuate" movements has to do with his inverted cusp teeth, whose masticating surfaces are as flat as if they had been leveled on the only plane of the world, which is in the possession of the Bureau of Standards, U. S. A. A flat surface has only two dimensions, width and length, and, as my trubyte articulator, according to Dr. Hall's view, gives only two-dimensional movements, I can ironically say that the trubyte articulator is the best instrument in which the inverted cusp teeth can be set up!

On page 51, second column, Dr. Hall writes: "To be more specific and to avoid any possibility of being misunderstood, I repeat that I do not believe in adjustable articulators for the various reasons to which I have called attention in my articles." And in another place he writes that, on my trubyte articulator, the working condyle cannot be adjusted, the balancing condyle also cannot be fully adjusted and the gothic arch cannot be fully adjusted. I can, therefore, ironically recommend to Dr. Hall my trubyte articulator as a "non-adjustable" articulator!

There are many other things in Dr. Hall's article to which I could reply, but I have no time to write a whole book simply for my defense and so I close. As our Swiss hero, William Tell, did not shoot his last arrow, so I also have not shot my last one in this article but have a whole bundle of good arrows still ready for the next defense.

COMMENTS ON DR. GYSI'S PAPER

By RUPERT E. HALL, D.D.S., Chicago, Ill.

THROUGH the courtesy of the editor, I have been permitted to examine the paper of Dr. Gysi, and I am impelled to make a brief comment. It is not my intention to indulge in a controversy with my friend Dr. Gysi or to make extended reference to what he has presented. I realize only too well the utter futility of attempting to settle this matter by the written word, and I feel that the profession has had enough of the articulator question and that it is not primarily interested in what Dr. Gysi says or what I say about it. If anyone should be sufficiently interested in the differences of opinion between us, it is merely necessary to read my previous articles,[1] to find any of Dr. Gysi's contentions fully answered.

However, for the purpose of refreshing our minds with what, in the greatest charity, seem to me some of Dr. Gysi's inconsistencies, I will cite one example as typical and then, in the words of my opponent, "leave it to the readers to form their own judgment."

Dr. Gysi claims that the movement of my mandible is abnormal.

In my article published in THE JOURNAL in September, 1929 (Figs. 86 and 87), I showed graphic registrations of the incisor point of my mandible as recorded in function (opening movement included—three-dimensional movement) and out of function (opening movement not included — two-dimensional movement), respectively.

I cited Figure 87, Gysi's gothic arch, especially to show that the movement of my mandible was normal, for the purpose of preventing the very criticism that Gysi is now making that it is abnormal, or worse still, that it is "monstrous" and "erratic."

We will recall[2] that in Dr. Gysi's article, "Hall's Automatic Anatomic Articulator," he set up his "test five" (Fig. 27[2]), as one that would prove arcuate movement of the mandible to be abnormal.

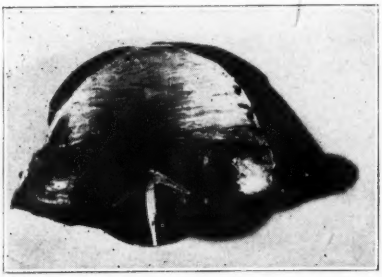
To further show Dr. Gysi that the movement of my mandible (arcuate) is normal and not abnormal, monstrous or erratic, I have made his "fifth test" with my own mandible and secured the same identical character of tracing (gothic arch) (see accompanying illustration), shown in his fifth test (Fig. 27) that he claims is indicative of normal. So test five, Gysi's own test, proves beyond equivocation that my case *is normal.*

Until Dr. Gysi will admit that the movement of my mandible is normal, there is no common ground of understanding between him and me on which to debate the subject.

1. Hall, R. E.: Full Denture Construction, J. A. D. A., 16:1157 (July) 1929; An Analysis of the Work and Ideas of Investigators and Authors of Relations and Movements of the Mandible, ibid., 16:1642 (Sept.) 1929; An Analysis of the Development of the Articulator, ibid., 17:3 (Jan.) 1930.

2. Footnote 1, third reference.

Permit me now to ask the question as to what is to be gained by keeping up a controversy with any one whose tendencies lead to such diverse conclusions and statements? The farthest thing from my mind is to antagonize Dr. Gysi or to attempt in the slightest degree to minimize the splendid work he has done in certain directions. No one honors him more than I do for some of his achievements and I have always cheerfully given him credit where credit was due. My only fear now is that Dr. Gysi will bring discredit on his own work and foster skepticism as to its value by the unaccountable attitude he has assumed in some of his recent utterances. How much better it would have been for him and for his profession if he had pursued the even tenor of his way and not indulged in controversy or sought to minimize the efforts of others. There is one lesson that Dr. Gysi should learn: no man ever gained a permanent advantage by trying to pull some one else down. Efforts of this sort are worse than wasted.



Gothic arch tracing of the incisor point of the author's mandible (Gysi's fifth test) with the graph plate and marker point disposed at an angle (approximately 30 degrees) to the occlusal plane.

In conclusion, permit me to express the hope that Dr. Gysi may enjoy a long and happy life and reap the reward that should come to him for his valuable contributions to dentistry.

USE OF DRUGS IN DENTISTRY; ADMINISTRATION, APPLICATION AND LIMITATIONS*

By JAMES E. AIGUIER, Ph.G., D.D.S., Philadelphia, Pa.

IN considering 300 returns from 1,000 questionnaires sent to members of the dental profession, and in talking before groups of dentists throughout the country on drugs and drug application, there is no doubt in my mind that many dentists do not give enough consideration to drugs and drug administration. Dentistry is so closely allied with medicine that the dentist of today must be a therapeutist. He is no longer considered only as an expert on restorations. You may call him the dental physician. As such, a dental specialist in medicine, he should be qualified to administer drugs. He should know drugs and drug application in regard to his specific field. He should know the physiologic action of all the drugs he uses and especially their limita-

*Read before the Section on Operative Dentistry, Materia Medica and Therapeutics at the Seventy-First Annual Session of the American Dental Association, Washington, D. C., Oct. 9, 1929.

tions. He should readily recognize signs of toxemia, idiosyncrasies and tissue reactions and know how to handle these conditions.

In drug administration, we should always keep in mind one important fact: Drugs are dangerous—we can do harm. The least amount of a drug that can be given and yet obtain results is what is to be desired. There is a grave tendency to overmedicate.

DRUG ACTION: SUSCEPTIBILITY TO DRUGS AND TISSUE REACTION

Idiosyncrasy.—A person who exhibits peculiar, pronounced reactions toward ordinary doses of drugs has an idiosyncrasy toward that particular drug. This is more pronounced in some individuals than in others, and there is a great variation in the reaction.

Tolerance. — Occasionally, an individual apparently does not react to the ordinary dose of a drug but has the power of resisting the action of a poison or of taking a drug continuously or in large doses without injurious effects.

Cumulative Action of Drugs.—In the administration of drugs, occasionally it will be observed that after a number of doses have been taken, with no apparent or but slight effect, suddenly symptoms arise which are much more pronounced than those manifested after the first dose. Such drugs as digitalis, strychnin, atropin, the iodids and arsenic belong to this group; as do also salts of mercury, lead and bismuth. Some of these drugs manifest their toxic effect in the mouth, which should be readily recognized by the dentist. Iodids cause salivation and give a characteristic odor to the breath. Arsenic causes a puffiness under the eyes, a metallic taste in the mouth and a garlic-like odor to the breath. Mercury causes salivation, a characteristic blue line on the gingiva, swelling and tenderness of the salivary glands and a characteristic odor of the breath. Lead causes a blue line along the gingiva, also blue patches on the cheeks. Bismuth, when used in considerable amounts over long periods, often shows its toxic effects in the mouth, causing the teeth to loosen and a blue gingival line to develop as well as blue patches on the buccal surface.

Drug Rash.—There are certain drugs, as well as some articles of food, which cause a skin eruption. Bromids will occasionally cause this disturbance. Iodids give a similar result. Iodin in the form of iodoform will bring about a marked disturbance of the intestinal tract and a skin rash in certain individuals. Salicylic acid and salicylates such as acetyl salicylic acid occasionally cause this disturbance. Quinin, belladonna, atropin, arsenic and antipyrin are included in this group. Mouth washes, powders and pastes also are included in this field. Mouth preparations containing salol (phenyl salicylate) salicylic acid or menthol, used over a long period, occasionally cause eruptions about the corners of the mouth and lower lip in susceptible patients.

Control of Pain.—Every dentist is called on to relieve suffering in the form of pain. Many practitioners are not doing all that is possible to relieve their patients. In cases of pulpitis, postoperative pain or severe pain of obscure origin which comes within the field of dentistry, local applications will sometimes afford relief for a short period. But there is no reason that the dentist should not resort to internal medication. He is qualified, he has had the necessary training and he rightfully should prescribe. If he does not do so, the physician is often called in to administer relief.

The group of drugs known as anodynes, sometimes referred to as analgesics,

are employed for the purpose of relieving pain. Anodynes are administered internally and act by inhibiting the sensory functions of the central nervous system. The foremost drugs of this group are opium and its derivatives, morphin and codein. Morphin, in one-quarter grain doses, or codein in half-grain doses, will give most satisfactory results. In cases in which narcotics are administered, we should not prescribe more than two doses: we should instruct the patient to repeat the dose in three hours, if it is necessary, and we should not inform the patient as to the identity of the drug, because of its habit-forming properties. A dentist must be registered with the Department of Internal Revenue to be eligible to prescribe narcotics. He should always bear in mind that he may at some time have to contend with habitues, who will use any means to obtain the drug they desire.

The salicylates and antipyretic group act as sedatives and anodynes. They probably quiet pain through some obscure central action or, as suggested, their effect is a depression of the basal ganglions in the neighborhood of the heat regulation centers through which afferent pain fibers pass. They are prepared synthetically. They are not habit-forming and seem most effective in pain of the neuralgic type. Acetyl salicylic acid is specially recommended. It is efficient and safe, and is not a cardiac depressant in ordinary doses. It may be given in from 5 to 10 grain doses every three hours, not over 30 grains being given in twenty-four hours. Acetanilid, acetphenetidin, antipyrin and amidopyrin (pyramidon) belong to this group, but they are inclined to be cardiac depressants. If there is a weakened heart muscle, we may have some reaction. There are many combinations of these drugs, and one should be familiar with the ingredients before attempting to administer them.

Sedatives.—Drugs employed for the purpose of reducing irritability of the central nervous system are used for patients who are highly nervous or apprehensive. The drug of choice in this group is bromid. It may be given in the form of a sodium bromid, potassium bromid or triple bromids, 15 grains three times a day. Barbital products have given satisfactory results in many of these cases.

Cardiac Failure.—Every dentist who gives a general anesthetic should have at hand a drug to use in case of cardiac failure. Although this is rare in a dental office, it is well within the range of possibility. The drug of choice is 10 per cent camphor in oil, 10 minims administered by hypodermic. Our second choice is caffein and sodium benzoate, one-half to one grain given hypodermically. These preparations should be kept on hand in units which are ready for use or in ampuls, the operator having at hand a sterile hypodermic syringe or a sterile solution, which likewise should be ready for an emergency. There is no hospital or institution of any size where general anesthetics are administered that is not prepared to meet this emergency.

Syncope. — Sudden unconsciousness, usually of short duration, the cause being an anemia of the brain, calls for emergency treatment, that is, change of posture so that the head is lowered, which results in a better blood supply to the brain. The drug to use in this case is ammonia water, 10 or 28 per cent by inhalation. It should be given preferably from a wide-mouthed glass-stoppered bottle, containing cotton to which a few drops of the ammonia water is added. To this, we may add a trace of oil of lavender and alcohol to make it more

pleasant for the patient. Amyl nitrite given by inhalation will prove very satisfactory.

APPLICATION OF DRUGS TO TOOTH STRUCTURE

Odontalgia or Toothache.—This may be caused by pericementitis, pulpitis or exostosis. In cases of exostosis, relief is to be obtained through surgical interference. For pulpitis, a saturated solution of chloretone in oil of cloves, 150 grains in 1 ounce, will give relief.

In cases of pericementitis, surgical interference and treatment with Talbot's iodin solution are advocated. Talbot's solution is preferred to other iodin preparations because we have the iodin content in a hydroglycerin base with zinc in the form of an iodid. The iodin gives the antiseptic value, and the zinc iodid the astringent properties, which are desirable in these cases. The absence of alcohol, which is present in many iodin preparations, is a further advantage, as alcohol in its concentrated form will destroy the mucous membrane of the mouth. If alcoholic solutions are used, they should be sufficiently diluted with water or glycerin. The selection of solution of chlorbutanol in oil of cloves is made because they both have marked obtunding properties, and the synergistic action of the two drugs gives a greater obtunding quality than could be obtained from any other application. The chlorbutanol has antiseptic properties which are not found in other anesthetics. Oil of cloves acts as a carrying medium and penetrates a thin layer of dentin.

Care of Drug: Preparations containing iodin should be kept in glass-stoppered bottles. Corks will disintegrate in a short time and the preparation deteriorate. These preparations should never be kept in closed cabinets where there is any metal, as the ever-present iodin fumes will corrode and destroy it.

An applicator for the preparation, once used in the mouth, should never be returned to the original container. If more than one application is needed, a little of the solution should be poured into a dappin dish, and none returned to the original container.

Oil of cloves changes from a light straw color to a dark brown. This is the result of oxidation, which gradually takes place when it is exposed to air. This causes deterioration, and we do not obtain the maximum efficiency from the drug. When this occurs, it is advisable to replace the solution.

Questionnaires on this condition (odontalgia) gave a list of fifty drugs or combinations of drugs, used by 300 practitioners. There were eight proprietary remedies, of which, in most instances, the ingredients were unknown. Some of the remedies recommended have no action whatever, and others are very destructive.

Pulpitis.—In acute simple pulpitis (inflamed pulp), in a majority of cases, the organ, being delicate, does not respond to medication, and a chronic condition develops, ultimately ending in a degeneration, which, of course, necessitates removal of the pulp. If an attempt is made to treat the condition, a sedative dressing of oil of cloves and chlorbutanol is sealed into the cavity for twenty-four hours. If the condition subsides, a temporary filling may be inserted to await developments, or oil of cloves and chlorbutanol, mixed with zinc oxid to form a paste, is used as a temporary filling.

Questionnaires give sixty-five drugs or combinations of drugs which were used for this condition. Twelve of these were proprietary remedies. Some preparations

were of no value and others are destructive.

Hypersensitive Dentin. — This indicates a state of irritation of the odontoblasts of the vital pulp. The irritation is produced only by external agents; i. e., physicochemical processes induce changes in the surface tension of the exposed contents of the tubules. The increased reactivity consequent on the disturbed equilibrium transmits any additional physical or chemical impulse at once, by the way of Tomes' fibers, to the odontoblastic cells covering the pulp, which are in direct contact with the nerve fibers of the plexus of Boll. When procain injection is not used to block off sensation from the entire tooth, a mixture of equal parts of potassium hydroxid and phenol crystals with a few drops of glycerin is smeared into the cavity after its walls are carefully dried. This will prove a very serviceable remedy provided we use the proper technic. It is carried into the cavity with a spoon-shaped excavator, and then, with a ball burnisher slightly heated, it is rubbed into the tooth structure. If we do not dehydrate before applying the drug, it will sometimes aid the action. We find that if we allow proper time, it will penetrate the dentin almost to the depth of 1 mm. It acts by abstracting moisture from the contents of the tubuli, thus preventing the transmission of sensation. This remedy is not infallible. Sometimes when this application is made, the tooth reacts so markedly that the preparation should be removed immediately by the application of warm water. Other means must be resorted to to control the pain. We usually get a certain amount of reaction on applying this paste. But it is not so severe as the pain incurred in the cavity preparation. We also find that its use is successful in the majority of cases.

Care of Drug: This medicament may be prepared by melting the phenol crystals, dissolving the potassium hydroxid in the melted phenol and adding a small quantity of glycerin to form a paste. If sufficient glycerin is not added, on solidifying the paste will crystallize. It cannot be applied in this form. This preparation is hygroscopic, and opening and closing the bottle will allow moisture from the atmosphere to be taken up by it, which will cause it to change from a solid to a semisolid or a liquid state, considerable, if not all, of its value being lost. The utmost care should be taken that the container is stoppered at all times, and when the stopper is removed, it should be replaced immediately.

The questionnaires advocated the use of thirty-seven different remedies for the condition. Seven advocated the use of formalin (solution of formaldehyd), which will desensitize, but also will devitalize. Six recommended devitalizing fiber, which would prove very destructive. Eight proprietary remedies were suggested. The manufacturers of some of the proprietary remedies print the formula on the label, using such names as "Trioxymethylene," which would have no specific meaning to many dentists. This is paraform, the polymerized form of formaldehyd, a very concentrated preparation which desensitizes but also devitalizes.

Cavity Sterilization.—The cavity is dehydrated by the use of a solution of chloroform one part and alcohol three parts, followed with a blast of warm dry air, and then by a 50 per cent solution of thymol in absolute alcohol. The antibacterial action of thymol is unusually high, and it lacks the irritating qualities that in many instances we find in other sterilizing agents.

Care of Drug: The volatility of the chloroform and alcohol solution naturally permits a change in the proportions of the dehydrating property which we are so desirous of retaining. The drug should be kept in a glass-stoppered bottle and, when needed, should be used from a dappin dish, carried by means of bibulous paper, but should never be used from the original container. In this way, we may prevent contamination of the stock solution and also check the evaporation which would take place in opening and closing the bottle. The solution of thymol should be applied from its container by means of an applicator, which may be made by winding a few wisps of cotton round the end of a long-handled broach. Fresh cotton should be used for each application.

In the questionnaire, about thirty different remedies were suggested for this purpose.

Varnish.—The ideal varnish is one that can be applied in a thin solution. The thick "messy" solutions are much harder to control and very difficult to apply to small cavities. The varnish should harden very rapidly, should be impervious to moisture and should act as a nonconductor. Gum copal has proved most satisfactory. The solution is prepared by heating the gum copal and driving off all volatile organic matter. The residue is then dissolved in a mixture of chloroform and alcohol. The cavity is coated with a thin layer of the solution and the warm air blast applied. It dries immediately and gives the ideal lining. With any varnish, the margins should be chiseled before the filling is inserted.

Care of Drug: The solution, the solvent of which is chloroform, will evaporate very rapidly; therefore, it is absolutely necessary to keep the bottle well stoppered at all times. For use, a small quantity may be transferred to a glass-covered bottle, such as is used for cement liquids, vaselin being smeared on the neck of the container, to prevent the cover from sticking.

A most serviceable applicator is a twentieth century long-handled broach with a wisp of cotton as a carrier. The cotton is held very firmly and it can be recharged readily. After the solution evaporates and becomes thicker, a small quantity of chloroform may be added to keep the solution at a proper dilution. For varnishing cavities, twenty-two medicaments were suggested in the answers to the questionnaire. Of these, only a few are varnishes; the others are more or less caustic, i. e., they give a definite caustic action, but they do not possess the necessary qualifications.

Pulp Capping.—This is a procedure which may occasionally be desirable and there are times when it may prove quite satisfactory. When clinically recognizable, involvement of the pulp is a very serious condition. If the exposure is not extensive and there is little or no hemorrhage, pulp capping may save the pulp. Experience has proved that this is an uncertain procedure, but a certain number of accidentally exposed pulps may recover after this treatment, especially in the teeth of young patients.

Two parts of zinc oxid and one part of thymol are mixed by melting the thymol and adding zinc oxid to form a mass. This is spread upon a glass plate to cool, forming a hard brittle sheet, which is then broken into small pieces. This material will melt at a very low temperature and immediate solidify on cooling. It is antiseptic, nonirritating and nonconductive of heat and cold. To apply, we place a small piece in a metal disk

or cap and heat slightly, but never in the flame, as the thymol is very inflammable. The cap, having been previously attached to an instrument by means of hard sticky wax, when the capping softens is placed over the exposed area and held to place until it cools, and the instrument is then removed with a twist. After the capping is applied, a cement covering is immediately placed over this for protection, and we then wait from four to eight weeks before placing a permanent filling. This remedy is selected because it is easily applied without pressure; which is essential. It is antiseptic and nonirritating, and it is a nonconductor of heat and cold; which is absolutely necessary.

Pulp Devitalization. — In cases in which the use of procain with pressure or local anesthesia is not selected, arsenic may sometimes, in the hands of the careful practitioner, be very serviceable. It should be applied only in the form of a fiber, that is, an arsenic paste in which cotton fibers have been incorporated. This gives the ideal preparation for handling. A very small amount is applied. A hundredth of a grain is more than enough to kill the pulp. Actual experiments in this particular field have proved that a millionth of a grain of arsenic is all that is necessary to kill a pulp. It should always be sealed in with cement in order to assure a permanent seal, as the slightest seepage will cause necrosis. It should never be used in teeth in which calcification is not complete, or in deciduous teeth.

Root Canal Cleansing and Enlarging.—To clean and open root canals, we advocate the use of diluted nitrohydrochloric acid, 1 part of hydrochloric acid to 4 parts of nitric acid, to which we add 5 parts of water, that is, in the reverse proportions found in the Pharmacopeia. This solution has proved most satisfactory. It has a great advantage over 50 per cent sulphuric acid in that the diluted nitrohydrochloric acid dissolves the tooth structure, while the sulphuric acid causes an insoluble sulphate to form, which has a tendency to clog the canal. The nitrohydrochloric acid should always be followed with sodium dioxid and water, which neutralizes and also aids in removing some of the débris. The diluted nitrohydrochloric acid should be used on a platinum broach, as it will destroy steel. Sodium dioxid is carried to the root canal on a broach charged with cotton previously dipped in chloroform to cause the salt to adhere. Water is then added to form a solution. Both acid and sodium dioxid are strong caustics. The patient should be protected to prevent injuring the soft tissues of the mouth.

Care of Drug: Dilute nitrohydrochloric acid should always be kept in a glass-stoppered bottle and should not be kept in a cabinet where instruments may be, as the fumes, which are always present, may cause damage thereto.

Sodium dioxid is very deliquescent or hygroscopic. When a small quantity is to be used, it should be placed in a dappin dish and any residue should never be returned to the original container. The containers should be kept stoppered at all times. If the substance is kept in a can, a lead washer should be used, and, if in a bottle, the latter should be paraffined each time after opening.

Root-Canal Treatment. — The selection of a suitable medicament for root-canal therapy is rather a difficult problem. Almost every known drug with any antiseptic property and many with no antiseptic properties whatever have been

used for this purpose. I quote the following from Prinz[1]:

> In regard to the application of powerful antiseptic drugs for the treatment of infected root canals, one should always be mindful of the following facts:
>
> (1) The agent must be able to develop the highest degree of antiseptic power without doing harm to the periapical tissues.
>
> (2) It must maintain its activity for at least twenty-four hours when sealed into the root canal.
>
> (3) It must not cause pain.
>
> (4) It must not discolor the tooth structure.

Our preference is for chlorin in its nascent state. There are various mediums by which the chlorin can be carried to the involved area. Ionization (electrosterilization) has proved very successful. About ten years ago, we carried on extensive work along this line, with very gratifying results. We have many of these results to show at the present day. The only objection was the cumbersome apparatus and the time involved in treatment.

Then dichloramin-T was advocated, and proved very successful in our experiments. These were carried out from eight to ten years ago and likewise gave very satisfactory results. The results hold to the present day. The objection to this product was its unstable character. If the operator was not watchful, the medicaments would deteriorate, becoming irritating, so that the condition was aggravated rather than relieved. We are now replacing dichloramin-T with a more stable product, having the same antiseptic value, camphor - monochlorphenol, i. e., a 50 per cent solution of monochlorphenol in camphor. The antiseptic action of the medicament depends on the slow liberation of nascent chlorin in the presence of active phenol, the camphor modifying the phenol and acting as an oily vehicle. This drug is active for from twenty-four to forty-eight hours. It is a stable product and has given most satisfactory results. When fistulas are present or when artificially established, this solution may be forced through by using a syringe. The solution does not have to be neutralized, and it is harmless to the soft tissues.

Many medicaments used in root-canal work are very strong caustics. There is no doubt that the proper application of these drugs will prove efficacious in many cases, but the tendency to overmedication, not only in root-canal therapy, but also in many other conditions, does more harm than good. There is no doubt that overmedication is practiced by a great many men in our profession and that many of their discouraging results undoubtedly may be attributed thereto.

Sealing Dentinal Tubuli in Root Canals.—If we desire to seal the tubuli in the root canal after sterilization, the canal is dried thoroughly with a mixture of alcohol and chloroform (3:1) and heat applied. A solution of rosin is then inserted and dried, the procedure to be continued until we are sure that all the tubuli are sealed. The rosin solution is made as follows: rosin, 15 grains; sodium bicarbonate, 4 grains; acetone, ½ ounce.

Root-Canal Filling.—There is no doubt that guttapercha is the ideal root-canal filling. The guttapercha cone will not suffice because of irregularity in the pulp canal. In addition to the point, we must have guttapercha in a plastic form. One of the easiest plastic forms for handling and manipulation consists of equal parts of baseplate guttapercha and white oil, white mineral oil or paraffin oil

1. Prinz, Hermann: Dental Materia Medica and Therapeutics, Ed. 6, St. Louis: C. V. Mosby Co., 1926.

heated on a sandbath (never apply the heat directly, as this will cause carbonization) until solution is effected. This may take several hours. The mixture is allowed to congeal, and it is then applied with a root-canal plugger, which is warmed and inserted into the paraffin-guttapercha. This immediately becomes liquefied, and is conveyed in this liquid form to the root canal. A sufficient amount is applied to fill the canal. The plugger is again warmed and inserted in the canal to make sure that the paraffin-guttapercha is in a liquid state. Then the guttapercha point, which has been previously selected, is forced to place. Guttapercha and chloroform may be used, but it is not so easy to manipulate.

Sterilizing Fissures of Teeth.—First, a 1 per cent solution of nitric acid is applied to remove all organic débris. It is allowed to remain a minute or two, and is worked into the fissure with a sharp explorer. This may tend to etch the enamel in the fissure slightly, which is desirable. It is dried and a saturated solution of silver nitrate, which is reduced with a 1 per cent sodium hydroxid solution containing a trace of formaldehyd (one part of formaldehyd solution to nine parts of solution of sodium hydroxid), is applied. Other solutions could be used to reduce the silver, but, with children, we try to avoid anything that would have pronounced odor or taste.

Care of Drug: Nitric acid when kept in glass-stoppered bottles is very stable. Silver nitrate also should be kept in a glass-stoppered, amber-colored bottle. Care should be taken to see that no chlorids or organic matter come in contact with the solution.

The solution of sodium hydroxid and formaldehyd is very unstable. This solution should be made fresh from time to time. A check-up should be made to see that the solution will reduce the silver before an attempt is made to use it.

The silver nitrate solution may be made by placing a crystal of silver nitrate on the bottom of a dappin dish, adding a drop of water and mixing with the butt end of an instrument.

APPLICATION OF DRUGS FOR DISEASES AFFECTING SOFT TISSUES OF THE MOUTH

Gingivitis.—This is a very common condition in most mouths. It may be very slight but, in many instances, is quite severe.

The drug selected for this condition is Talbot's solution of iodin or glycerol of iodin, the formula of which is as follows: zinc iodid, 15 parts; water, 10 parts; iodin crystals, 25 parts; glycerin, 50 parts.

This gives us rather a thick liquid. We have a modified Talbot's solution which we find more serviceable: zinc iodid, 3 drams; water, 10 drams; iodin crystals, 5 drams; glycerin, 20 drams.

For treatment of laceration of tissues of the mouth, or when an antiseptic of reasonable strength is desired in treating wounds of the mouth, or in helping to establish hygienic conditions in the mouth when stomatitis exists, we may use Talbot's solution of iodin, immediately removing excess by irrigation with some mild antiseptic solution. This formula for Talbot's solution is found only in dental textbooks, and there is at times some difficulty in having it prepared. The zinc iodid is dissolved in water; the iodin crystals and the glycerin are added, and the preparation is allowed to stand until solution is effected.

Talbot's solution has many advantages over other preparations. The zinc iodid acts as an astringent. This action is very desirable because of the inflammation present. The iodin gives the

antiseptic property which is desired, and the water and glycerin act as a harmless vehicle. Tincture of iodin should never be used in the mouth, because of its caustic nature. The 95 per cent alcohol present destroys mucous membrane by coagulation. The questionnaires for gingivitis gave sixty different preparations or drugs, eighteen of these being proprietary.

Vincent's Infection. — Vincent's infection is known as ulcerative stomatitis or trench mouth. Here, we use a solution of chromic acid, 8 per cent, which is applied with a cotton applicator to the entire gingiva as well as all areas which appear on the buccal mucosa or lip, if these are involved. In cases in which third molar pockets exist, which are quite common in most mouths as the third molar does not fully erupt, and there is always a pocket equivalent to the depth of enamel below the gum; or in overhanging crowns or in pockets around subgingival fillings, copper sulphate in a very fine powder is packed into the pocket with an iridioplatinum loop applicator or other suitable instrument previously dipped in water to cause the copper sulphate powder to adhere. The pocket is sealed with white vaselin (petrolatum) to keep the saliva or fluids entering the mouth from carrying the copper sulphate away before it has had time to carry out its work.

A suitable mouth wash, preferably one containing oxygen, should be given the patient for home use. The patient's cooperation, especially with home medication, will assist materially in effecting an early result. The following mouth wash is advocated: a scant ¼ teaspoonful of salt; scant ¼ teaspoonful of powdered borax; teaspoonful to tablespoonful of hydrogen peroxid; large glass of hot water. This solution is made fresh when needed and used every three hours. The patient is instructed to hold portions in the mouth for one-half minute by the watch until the entire solution is used. This is a fresh solution of sodium perborate. Sodium perborate could be used, two teaspoonfuls to a glass of hot water. It is more expensive, and there is also the question of the proper drug's being dispensed. Neighborhood drug stores have dispensed borax which is sodium biborate.

Care of Drug: Chromic acid in 8 per cent solution has been selected as we find this will destroy the organism and do little or no harm to the tissues of the mouth provided we are careful in the technic of application. A much weaker solution would not destroy the organism, nor would it affect the tissues of the mouth, but a much stronger solution, while destroying the bacteria, would also destroy a certain amount of healthy tissue.

To apply, a quantity is placed in a dappin dish and a cotton applicator used, none of the solution being returned to the original container. The teeth should be blocked off with cotton rolls or gauze. In applying the chromic acid solution, no pressure should be brought on the soft tissues. The applicator should rest on the tooth structure. By a rotary motion of the applicator, a drop of the solution is forced into the interproximal space and along the gingival trough. By capillarity, the solution will penetrate a considerable depth. It should be allowed to remain for two or three minutes, and any excess removed with cotton or bibulous paper to prevent its coming in contact with the soft tissues of the mouth, which it may cauterize. Some mouths are more susceptible to caustics than others, even in this strength. Again, we call attention to the grave tendency toward overmedica-

tion. This should be applied not oftener than once in twenty-four hours. Copper sulphate should be used in an anhydrous powder, that is, one so fine that there cannot be discerned by the sense of touch any evidence of crystalline form. In using the coarse powders, the minute crystals may have a tendency to irritate the tissues. In applying copper sulphate, care should be taken not to use too much at one sitting. This being an emetic, it may tend to nauseate the patient if a sufficient quantity should get into the stomach. We usually select three or four teeth to pack, carefully wiping away any excess powder, and not allowing it to remain in the mouth; then applying petrolatum to seal the pocket. The patient is then instructed not to eat, drink nor swallow for a period of one hour. This would give sufficient time for the drug to act. Chromic acid should be applied at twenty-four hour intervals and, as the case improves, the interval should be lengthened. Copper sulphate likewise should be applied at twenty-four hour intervals and the interval increased as the case progresses. Chromic acid solution should never come in contact with organic substances. Cork or rubber stoppers will decompose it. Alcohol should never be mixed with the solution. It should be kept in an amber or blue glass-stoppered bottle.

For Vincent's stomatitis, we have, in the questionnaire answers, forty-two preparations recommended, seven of these proprietary.

Aphthous Stomatitis or Canker Sore.—The drug selected for this condition is zinc chlorid in an 8 per cent solution. In this strength, it will eliminate the infection, but will not in any way harm the healthy tissues. To apply, we dry the surface with cotton or gauze, and then, with a cotton applicator, cover the affected area with a solution of zinc chlorid, holding it there for a minute or two. This is followed with an application of Talbot's solution of iodin. In most cases, one treatment will suffice. We never apply the treatment oftener than once in twenty-four hours, and we find occasionally that it is necessary to make two and, in extreme cases, three applications before the condition is under control.

The application of strong caustics is to be discouraged as there is considerable difficulty in controlling any liquid, and, if applied on a moist mucous membrane, there is always a possibility of extensive destruction.

For canker sore, we have forty-eight drugs recommended in the questionnaire answers. There is a tendency to use the stronger caustics, which I would discourage because there is a possibility of destroying healthy tissue which is adjacent to the area involved.

Mouthwash.—In the oral cavity, we have a delicate mucous membrane and glands which secrete a solution that is physiologically balanced and contains enzymes, which are sensitive; hence, the simplest and mildest solution that may be efficacious is what is desired. According to Prinz,[2] a good oral preparation should possess the following properties: 1. It must be absolutely indifferent in regard to *(a)* the mucous membrane—noncaustic; *(b)* the teeth — nondecalcifying (mechanical or chemical); *(c)* the organism as a whole—nonpoisonous. 2. It must not interfere with the normal physiologic cleansing of the oral cavity, i.e., (*a*) it must not inhibit the secretion of saliva; *(b)* it must not perceptibly alter the reaction of saliva; (*c*) it must not destroy the ferments of saliva. 3. It must possess

2. Prinz, Hermann: Diseases of the Soft Structures of the Teeth and Their Treatment, Philadelphia; Lea and Febiger, 1928.

sufficient cleansing action, combined with good taste and odor.

The tendency to overmedicate is practiced in the field of mouthwashes more than anywhere else. It has been demonstrated that a mildly alkaline physiologic sodium chlorid solution is most effective. The following is a simple wash, containing these qualities with the addition of a small quantity of oxygen, which gives the added mild antiseptic value: one-quarter teaspoonful of salt; one-quarter teaspoonful of borax; 1 teaspoonful hydrogen peroxid; 1 glass of hot water. Great interest has been displayed by the profession regarding the relative merits of certain preparations used in this field.

The following experiments were carried on by J. L. T. Appleton and K. Polevitzky in the School of Dentistry of the University of Pennsylvania to determine the relative antibacterial effects of mouthwashes.

1. Metaphen; effective concentration 1 in 5,000 (0.2 in 1,000).[3]

2. Hexylresorcinol; effective concentration 1 in 2,000 (0.5 in 1,000).[4]

3. Sodium-ricinoleate; effective concentration 10 in 1,000.[5]

4. Lavoris, effective concentration one-half strength.

Equal volumes of the same suspension of saliva were subjected to each of the four above-mentioned solutions for exactly three minutes, and then the number of bacteria surviving was determined. The number of bacteria in the saliva suspension immediately before and immediately after these tests was determined. This was necessary in order to have a standard (or control) by which the antibacterial effect of the mouth-wash solution could be judged. All of these tests were done in duplicate and the average was taken.

The results are graphically represented on the accompanying chart. Because of the great difference in numbers of bacteria in the controls (*C/B* and *C/A*) and in the test proper, it was necessary to chart the results on "semilog" paper. The absolute numbers of bacterial colonies counted are given by the figures at the upper right of each column.

If we take the average of the two controls as 100 per cent, under the conditions of this experiment the relative efficiency of the mouthwash solutions may be represented as 99.83 per cent (metaphen), 99.89 per cent (hexylresorcinol), 99.39 per cent (sodium ricinoleate), and 83.88 per cent (lavoris).

The concentrations used were those recommended for the purpose of a general mouthwash (except in the case of lavoris, which was stronger).

In judging the value of a mouthwash, it must be remembered that high antibacterial action is not the only property to be desired. The solution must be nonirritating to the oral mucosa. These tests throw no light on this requirement.

Irrigation of the Antrum.—Where pus is present, potassium permanganate solution 1:5,000 is most serviceable, as it gives the antiseptic qualities necessary and also acts as an indicator. As long as any pus is present, the permanganate is decomposed; instead of returning with its characteristic wine color, it returns in a straw color. When the antrum is free from pus, the wine color returns.

Physiologic sodium chlorid solution is most serviceable and is an ideal wash for this particular purpose. Of course, it has

3. Bunting, R. W.: Dent. Cosmos, 68:931 (Oct.) 1926.

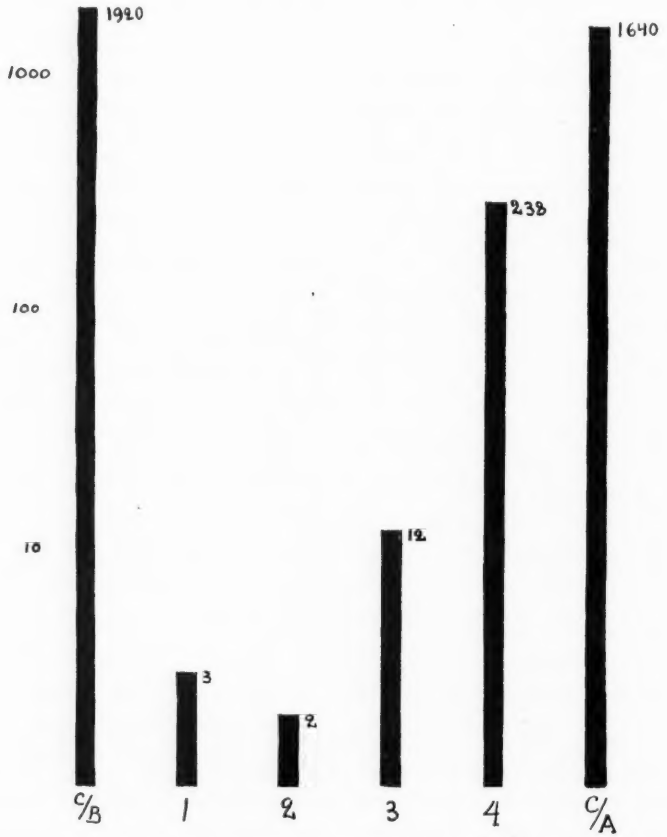
4. Feirer, W. A., and Leonard, Veeder: Dent. Cosmos, 69:882 (Sept.) 1927.

5. Hartzell, T. B.: Factors in the Control and Cure of Pyorrhea, J.A.D.A., 14:2059 (Nov.) 1927.

not the indicating qualities which are found in the potassium permanganate solution.

Care of Drug: Potassium permanganate is a dark purple or violet-red crystalline substance. It is very stable, needing no special care. As solutions of potassium permanganate are readily decomposed by organic matter, it should not be kept in containers with cork or rubber stoppers. Alcohol is incompatible. The solution should be freshly prepared as needed.

Irrigation of Sockets.—For this, Dakin's solution (surgical solution of chlorinated soda) has given very gratifying results. This is a neutral solution con-



Relative antibacterial effects of mouth washes. The heights of the columns represent the logarithms of the number of bacteria. The figures at the upper right of each column are the absolute number of bacteria surviving treatment. *C/B*, control at the beginning of the tests. *C/A*, control at the end of the tests. *1*, metaphen 1 in 5,000; *2*, hexylresorcinol (S. T. 37), 1 in 2,000; *3*, sodium ricinoleate, 10 in 1,000; *4*, "lavoris," 1 in 2.

taining about 0.5 per cent available chlorin. When it is not convenient to have this made fresh, which it should be each day, the tablet form is very satisfactory for making the solution. It should always be warmed before being applied to sockets and where the deeper structures are involved. The drug is very unstable in solution and should be prepared fresh for each application.

Hemorrhage.—This includes not only hemorrhage following extraction, but accidental laceration of the soft tissues of the mouth with disks, burs or instruments. The gum margin, particularly when cavities are being prepared, often starts oozing or bleeding. These conditions can all be controlled by a physiologic hemostatic. This does not rule out the use of some form of iodin or other antiseptic as a preliminary to minimize the possibility of infection. Sometimes, this application of an antiseptic will arrest the hemorrhage, but when this fails, the physiologic hemostatic should be resorted to. The various textbooks, with the exception of one or two very recent editions, invariably advocate the use of drugs which control this condition by a chemicophysical process. We have now, thanks to Howell and Hess, a physiologic hemostatic known as thromboplastin. It contains the lipoid substances of brain tissue (ox) in physiologic sodium chlorid solution.

Natural coagulation of the blood involves the transformation of soluble fibrinogen to the insoluble fibrin. The activity responsible for this transformation is attributed to the fibrin ferment, thrombin. Delayed coagulation of the blood may be attributed to a deficiency of any one of the essential factors in clot formation, and the therapy indicated is dependent on the element missing in the cycle of fibrin production. Thromboplastin is marketed in a solution for hypodermic use and also for local use. For the latter, it should be held in place on a piece of gauze under some pressure and never used as a swab.

It should always be borne in mind that thromboplastin acts on the bood and not on the tissues. Therefore, it is necessary to hold it in position under compression for a minute or two, to prevent the dragging away of the clot web formed at the orifices of the capillaries. If necessary, the packing may be left for a period of twenty-four hours. If we are packing for a period of twenty-four hours, we should use gauze in preference to cotton, and we may use iodoform gauze, which has no deleterious effect on the drug.

Care of Drug: All biologic preparations are subject to deterioration and are given an advance dating of two years. This means additional strength is given so that at the end of a two-year period, we still have 100 per cent efficiency. This plan is employed in dating all biologic substances. After the date stated, they are still effective, but with a strength constantly diminishing from 100 per cent. If kept in a cool place, they deteriorate much less rapidly. Thromboplastin, like other tissue derivatives, deteriorates with age. It loses its potency more rapidly in open packages than when carefully stoppered. It should be kept in a cool place, carefully stoppered at all times and returned after the expiration date shown on the label. Under no circumstances should cotton, gauze or instruments of any type be put into the container of any biologic preparation, as this will hasten deterioration. A dappin dish should be used and a few drops placed in this for use, none of the drug which has been taken out of the original container being returned to it.

For hemorrhage, we find in the questionnaire answers twenty-three preparations mentioned, three of which are proprietary. It is very gratifying to see that at least 112 of the men are using thromboplastin, which indicates that they are very anxious to find remedies that will service their various needs.

The Painful Socket.—The treatment of this condition is a much-disputed question and we do not claim that we have as yet found the ideal remedy. We have been using a mixture of procain hydrochlorid and balsam of Peru, which we have found very efficacious. A suitable piece of iodoform gauze is saturated by dipping in balsam of Peru and is then placed on a piece of sterile gauze. Procain hydrochlorid powder is sprinkled over it and it is then carefully packed, without pressure, into the socket, which has been previously dried. This usually gives relief for from twenty-four to forty-eight hours, and then another packing is inserted. We do not feel that this is infallible. We do believe that an anesthetic is to be desired or is preferable to any other medication. You may use, if you wish, the insoluble anesthetic, such as ethylaminobenzoate. But when we have this condition, if a soluble anesthetic is used, such as the procain hydrochlorid, there is a quicker action from the initial dressing; and then, with the balsam of Peru, which retards the solution of the salt, there is a period of activity lasting from twenty-four to forty-eight hours.

SUMMARY

1. The dentist should be familiar with drugs for internal medication in treating conditions which come within his field of activity.

2. He should write prescriptions and prescribe narcotics when necessary; and he therefore should be registered with the Department of Internal Revenue.

3. He should have at least one drug on hand to treat any condition that may arise.

4. He should know the action of all drugs that he uses and especially the care necessary to keep and administer them.

5. He should be cautious regarding administration or application of drugs for fear of overmedication.

Medical Arts Building.

DISCUSSION

Ewing P. Brady, St. Louis Mo.: Dr. Aiguier has warned us not to prescribe drugs promiscuously; I find that we can put more blame on ourselves in not prescribing enough. We are used to taking some of the prescriptions given to us by the manufacturers of products, and signing our names to the bottom of them, and simply saying, "Get this at the drug store." The fault lies in the fact that we do not know enough about prescription writing, because we do not write enough prescriptions. Dr. Aiguier mentioned Talbot's solution. The druggist usually dispenses tincture of iodin instead of crystals of iodin. Nearly all of these preparations are made up in such a way that the dentist does not get the preparations which they have prescribed. Taking Talbot's solution as an illustration, permit me to show you how to master prescription writing as an aid to writing prescriptions in the future.

Zinc iodin .....15% × 5 × 4
Aquae (?) .....10% × 5 × 4
Iodin crystals .....25% × 5 × 4
Glycerin .....50% × 5 × 4

"× 5" refers to 5 grains to the ounce, giving a 1 per cent solution. "× 4" refers to the quantity of solution that we wish; in this case, a 4-ounce mixture. Now if we multiply through by 5, we will get the quantity of drugs to use; a very simple method of writing prescriptions. For instance, if we want more than 1 ounce, and wish to fill a 4-ounce bottle, just multiply this by 4. If we would write a prescription once in awhile, we would not have some one come in and insult our intelligence on the question of prescriptions. As regards the matter of control of pain,

there is the nervous apprehension, and these nervous patients say, "You can't prepare a cavity unless you use procain, etc." I think it has resulted in a vicious and dangerous habit on the part of the patient of dictating to the dentist. This should be controlled in another way. It is far better to prepare a patient and allay this nervous apprehension. There are many formulas which are published, so that we know what they contain. And besides, if we wish to control the pain as well as the nervous apprehension, we may add an anodyne. We have been using oil of cloves and eugenol. A word of warning should be issued in the preparation, for instance, of oil of cloves. If we go into the open market or drug store, we get a heavy dark brown preparation of oil of cloves. I have seen oil of cloves which has assumed a semisolid state. During the past few years, I have been buying not the eugenol, but the oil of cloves bud. It is a very thin greenish lymph liquid, and it has not nearly the viscosity of the oil of cloves as we ordinarily purchase it on the market. In the treatment of the root canal, I make but one suggestion. Dr. Aiguier has suggested that we use chlorbutanol. I have had great success with monochlorphenol. I have been using monochlorphenol, a half tablet in a dappin dish, mixed into a stiff paste. We know that the glycerin will take up moisture, and when we place this in the canal, we have a dual action. First, the glycerin will attack the moisture in the periapical region, being a deliquescent substance; secondly, the chloramin acts as an antiseptic by substitution, and it also solidifies the gases of putrefaction; and thirdly, we have the bleaching property. It is not irritating, and I have had no trouble with decomposition. When we place this oil in the tooth, it is hard to get it out again in future treatment, so I have discontinued its use. The use of copper sulphate was mentioned. I have been using the anhydrous and find it is very efficacious; in fact, it stays where you put it. Dr. Aiguier mentioned in his paper that he uses Talbot's solution. I might say that I place a small quantity of ethylaminobenzoate in this preparation. I use 1 fluid gram of benzyl alcohol, and have had fine results from its use. As regards the use of mouth washes, this is one of the most important phases of this entire preparation. We should not accustom ourselves to consider the mouth wash as we have in the past, that is to say, we should use it more or less as a toilet article. We should consider what pathologic process is present, and what the patient needs, that is, some preparation specifically useful for the case under discussion. If we do this, we can eliminate some of the proprietary preparations on the market.

Dr. Aiguier (closing): There are very few proprietary remedies that have been accepted. The majority of them are worthless. In prescribing medicines, we find that some of the recent graduates, when called on to prescribe, are inclined to give the maximum dose of any drug they may use. We have always advocated and emphasized the fact that caution should be used at all times in administering and applying medicines. To supplement Dr. Brady's talk on prescription writing: The dentist who intends to prescribe medicines and write prescriptions intelligently should spend some time in the study of prescription writing. He will find that he can obtain considerable help from his friend the pharmacist. It is not unusual for the recent medical graduate to confer with the pharmacist from time to time to improve his prescription writing. I have always thought that the dentist could well follow his example. As regards the use of barbital products, we know that they have a cumulative action and should be used with discretion. We should not prescribe for an individual who has the habit of taking drugs for sleeplessness day in and day out over any extended period. This I consider is out of our field. In this type of case, were barbital products used, we would undoubtedly have a cumulative action, which would in some cases be quite severe. In root-canal therapy, we believe that no matter what drug one uses, provided it has antiseptic properties and is used properly, one stands a fair chance of getting results. When I mentioned the use of copper sulphate, I had in mind the anhydrous copper sulphate, which is a very fine powder and can be obtained at any drug store at a reasonable cost. In closing, may I again emphasize two points: Do not overmedicate and beware of proprietary remedies.

ESTHETIC AND FUNCTIONAL DEVELOPMENT OF THE UPPER LIP, TOGETHER WITH ITS USES AS A RETRACTIVE FORCE FOR DISPLACED ANTERIOR TEETH*

By NORRIS C. LEONARD, D.D.S., Baltimore, Md.

MY excuse for presenting this short paper is the apparent neglect of what may properly be regarded as a very important and ready functional aid in the correction of certain types of malocclusion of the dental arches, this slightly exaggerated function being utilized at the same time for esthetic development or modification of soft tissues adjacent to the teeth and affecting materially the general facial balance and expression.

The functions of the lips and their anatomic construction are too well understood to require description here. Their esthetic value and architectural forms are obviously modified to a very large extent by the arrangement of the teeth, and the latter, in turn, is influenced by both normal and perverted functioning of the lips.

Good facial balance with harmonious lines should be the chief ideal in the art of our specialty; and the pose of the lips, the supreme test of our success. The approach to perfection in this ideal would contemplate, of course, not only good occlusion of the teeth but harmonious bony development as well, together with an adequate amount of soft tissue covering to permit normal functioning and free muscular response to the usual emotions.

I think that a close study of the facial forms of orthodontic patients will reveal that a considerable percentage of even the treated cases show a lack of harmonious result, due to a shortness of the upper lip, which has been caused by interference with normal lip function from malposed teeth and misshapen dental arches. The treatment of this deformity comes well within the field of our specialty and is certainly of sufficient importance to engage our serious attention. Any persistent interference with muscular function acts as a restraint on normal development of these soft tissues, just as certainly as overactivity tends to produce excessive development. This, I think, holds true, within certain congenital limits, of practically all tissues of the body.

In cases of excessive protrusion of the maxillary incisors, particularly in those associated with narrow arches and habitual mouth breathing, the functions of the upper lip are so disturbed or perverted that development is often arrested to such an extent that the patient is disfigured, even after the arch deformity has been corrected.

Removal of the physical obstruction by correction of the arch form that has re-

*Read before the Section on Orthodontia at the Seventy-First Annual Session of the American Dental Association, Washington, D. C., Oct. 9, 1929.

strained the lip activity and thus contributed to its deformity, of course, automatically tends to encourage a restoration of lip function that will insure some further development. But, in the meantime, certain muscular inhibitions have become habits that are slow to overcome, and these act as a positive retarding influence.

What it seems to me is clearly indicated is some stimulating mechanical influence that will aid in development of the lip by a sort of reversal of the physical conditions that caused the deformity. By this, I mean some controlled mechanical form held under the lip in such a way as to place the tissues that need development under tension and produce a sort of stretching effect on the lip. At the same time, such a device can be so constructed as to utilize the reciprocal of this force in such a way as to retrude and aline malposed maxillary teeth, including, perhaps under favorable conditions, some distal movement of the molars.

An appliance which I have been using for these purposes with great satisfaction for some time is in the form of a labial arch, having a broad extension in the under-lip space. It is attached to tubes on the buccal side of molar bands in the usual way, and is made of 18 gage wire, which is anchored anteriorly to an under-lip section made of vulcanite or hecolite molded to fit and completely fill this space between the cuspid eminences, and extending from the superior lip attachment to a line slightly above the gingival border. Just distally from the cuspid region, a 22 gage wire is attached vertically at right angles to the arch wire, which has been placed slightly above the gingival margins. The smaller wire is then bent at right angles, extended across the labial surfaces of the anterior teeth, slightly lower than the usual labial arch, and attached in the same manner on the opposite side.

The under-lip section of vulcanite or celluloid composition should be so shaped as to be quite thin at the edge next to the cervical border and thick toward the upper border; that is, as thick as comfort and contours will permit without too obvious distortion of the lip and without being too much in evidence when the patient smiles.

The wedge-shape of this under-lip section not only places the greater tension on the soft tissues, where development is needed, but also acts as a fulcrum over which the lip may be stretched in natural functions and exercised. Besides, this form balances the force and obviates any tendency to slip out of place.

When the small wire arch is so bent as to bear against the teeth, the elastic force and weight of the lip that is under tension so react on the teeth and supporting tissues as to secure a reciprocal and constant working force. By throwing the arch forward by a nut or spring in front of the buccal tubes, the operator increases the tension against the lip and proportionately distributes the force against the anterior teeth as well as distally on the molars. This also makes an excellent device for increasing the length of the upper anterior teeth, or rather moving them downward where this movement may be indicated, as in many cases of open bite, tongue sucking, etc., and also for closing spaces.

This arrangement will also eliminate the necessity for use of intermaxillary elastics in many cases where they would otherwise be indicated for retraction of upper anterior teeth.

The device can be easily removed by the patient for cleaning. It has possibilities also as a practical retainer, though,

so far, it has not been developed for this purpose.

DISCUSSION

Dr. Jackson, Ann Arbor, Mich.: Those of you who listened to Percy R. Howe's address will remember that he referred to the fundamentals of dentistry and its advancement, and that he clearly and definitely stated that the dentistry of today, while mechanical in its technic, was using mechanics only as an adjunct to biologic, physiologic, pathologic and bacteriologic processes. We who are more interested in orthodontia must remember that mechanics is but an adjunct, and that there are physiologic and biologic problems which must be remembered and considered in each case that we undertake. The great failure of orthodontia, as I see it, basing my conclusions upon more than sixty years of observation and practice, is that, in the more involved cases, little or no consideration is given to the physiologic and biologic aspects of the particular case studied. Whether this is due to faulty education or failure to recognize the importance of these subjects, I cannot state. I am inclined to believe that it is the result of faulty instruction rather than an absence of receptivity on the part of the individual. A study of comparative anatomy is or should be a fundamental in any orthodontic course, for only by this means can we recognize the relationship and origin of the bones of the face. Years ago, we had a most excellent text known as "Owen on the Skeleton." For clarity of expression and reasonableness of theory, I have yet to find its equal. In this work, Owen used the fish as the basis, because the medullary canal is in a straight line from lip to tail, while in man the great central ganglion is so enlarged that the spine is curved upon itself, the back being considered the front by most individuals. The vomer, a continuance of the spine, is attached to the premaxillary segment, from which the upper incisors arise. The prehensile cuspids are attached to the anterior portion of the maxilla close to the suture of the maxilla and premaxilla. This union is labile in character for many years, and the cancellated tissue of the alveolar process that holds the teeth has like labile characteristics, so we as orthodontists should avail ourselves of this fact or characteristic and with pads move the process bodily with the teeth *in situ*, and not by pressure on the teeth alone. I am glad to see that Dr. Leonard has made use of the principle of moving of the process. Too little recognition has been given this in recent years.

OPERATIVE DENTISTRY IN CHILDHOOD AS RELATED TO ORTHODONTIA*

By E. F. SULLIVAN, D.D.S., Boston, Mass.

THE objective of operative dentistry for children and of orthodontia has changed. Today, prevention of dental disorders leading to impaired health is the watchword of both, rather than solely curative procedures.

As J. Lowe Young said five years ago, at the twenty-fourth annual meeting of the American Society of Orthodontia in Kansas City, "The problems of the orthodontists are the prevention and correction of malocclusion, and here, as in all medical science, prevention is far more desirable than correction."

There are no two branches of dentistry so dependent or so well qualified to make dentistry a real health service as children's dentistry and orthodontia. To make dentistry available as a health

*Read before the Section on Orthodontia at the Seventy-First Annual Session of the American Dental Association, Washington, D. C., Oct. 9, 1929.

measure, there obviously must be close cooperation between the dentist and the orthodontist, together with a deep appreciation of their mutual responsibility for the greatest possible benefit to the patient.

Operative dentistry for the child, hereafter referred to as children's dentistry, has for its objective the maintenance of health through the prevention or control of dental caries; assuring the vitality and integrity of the individual teeth, deciduous and permanent.

Orthodontia has for its objective the health of the patient through proper function of the teeth and related structures.

To establish and maintain oral and general health is accepted as the culmination of the united efforts of the orthodontist and the children's dentist. There must be no misunderstandings. Cases in which they are interested should be cared for in the spirit of mutual, friendly understanding of each other's problems.

While it is common knowledge that the child has in the past been shamefully neglected by the profession at large, this does not necessarily cause despair on the part of the thinking orthodontist.

Orthodontia and children's dentistry are today accepted as the most efficient, conservative and constructive type of service known. Oren A. Oliver says[1]: "He who advises parents to let the deciduous teeth alone and that it is useless to treat deciduous teeth simply because he dislikes children's work is guilty of the grossest malpractice and works untold injury upon suffering humanity."

Invariably the dentist sees the child and parent long before the orthodontist does. In order to facilitate his service, he must influence and educate the child to be a tractable, appreciative client, in order that a régime of mouth hygiene may be established.

The diet of the patient should be looked into and, in a general way, suggestions as to its correction or improvement made.

The dentist serving children should be on the watch for manifestations of pernicious habits such as thumb-sucking or finger-sucking, mouth-breathing, tongue-swallowing, lisping, tongue protrusion, cheek-biting, perverted muscular actions, etc., and make every effort to correct them.

The importance of close observation of the mouth during exfoliation of the deciduous teeth and eruption of the permanent ones cannot be overemphasized.

In an operative sense, children's dentistry is of inestimable value to the orthodontist in the preservation of the mesiodistal diameter of the teeth; the prevention of premature loss of deciduous teeth and of overretention of deciduous teeth; judicious extraction of deciduous teeth; insertion of space retainers; maintenance of mouth cleanliness, etc.

From the foregoing, it is obvious that when the time comes to seek orthodontic service, the child is presented under the most favorable circumstances.

It is no secret that there is considerable difference of opinion among orthodontists in regard to the matter of instituting orthodontic measures during deciduous dentition. This diversity of opinions does not relieve the children's dentist of his responsibility in referring cases to the orthodontist at the first indication of a deviation from normal during primary dentition.

G. F. Cale Matthes has observed that "malocclusion in permanent dentition must be inevitable if any irregulari-

1. Oliver, O. A.: Internat. J. Orthodont., 15:422 (May) 1929.

ties of the occlusion are present in the deciduous dentition."

The dentist rendering full service to the child is morally obliged to explain to parents the necessity for orthodontic interference, if indicated, and strongly advise treatment.

Your principles relating to dental health are known to all present, and we in turn subscribe to them in every detail. We wish that you would continue to emphasize the need of operative dentistry in childhood before and during orthodontic procedures in order that we may better serve the child and supplement your efforts.

As one of America's eminent orthodontists has said, "The moment the physical condition of the mouth shows neglect, the orthodontist's whole field of endeavor becomes an illogical gesture."

520 Beacon Street.

CAVITY PREPARATION FOR INLAYS TO BE USED AS BRIDGE ABUTMENTS IN FIXED BRIDGEWORK*

By ROBERT E. BLACKWELL, M.S., D.D.S., F.A.C.D., Chicago, Ill.

IN this consideration of cavity preparation for inlays to be used as bridge abutments in fixed bridgework, the order of procedure will be followed which the late G. V. Black gave to the profession in his standardized system of cavity preparation. As you will recall, the several steps are: Obtain (1) the outline form, (2) the resistance form, (3) the retention form, and (4) the convenience form; (5) remove the remaining carious dentin; (6) plane the enamel wall and bevel the cavosurface angle; (7) make the cavity toilet. This system of cavity preparation has stood the test of time. It was worked out during years of study of the principles involved, and, as has often been stated, needs modification only in minor detail to be adapted to inlay work.

In a critical study of the outline form for a cavity to be used in bridgework, the subject of extension for prevention is important. In fact, it might be considered of more importance here than in cavity preparation for fillings because of the greater outlay of time and money required in bridge construction. These factors make failures in bridgework more disastrous to the patient and to the dentist.

As this paper deals simply with cavity preparation for bridgework, only the outline form for proximal cavities will be considered.

Extension for prevention means the laying of cavity margins in areas where decay will be unlikely, or less likely, to occur. It means that, in accomplishing this end, sound tooth structure must be cut away. It has nothing to do with the removal of carious enamel or carious dentin. It means that the buccal and lingual margins must be placed close enough to the axial angles to be cleaned by the friction of food during mastication. It

*Read before the Section on Partial Denture Prosthesis at the Seventy-First Annual Session of the American Dental Association, Washington, D. C., Oct. 8, 1929.

has come to mean that the gingival margins of cavities should be placed under the free margin of the gum because decay does not begin under healthy gum tissue.

Dr. Black has shown that on the proximal surface of every tooth, there is an area which may be involved in decay if a person is susceptible to dental caries. (Fig. 1.) This area of liability varies in shape and extent and is influenced by the contour of the proximating surfaces, the position of the gum septum and the occlusion. The buccal and lingual embrasures are formed by the rounding away of the proximal surfaces from the contact point toward the buccal and lingual angles, and therefore the width of the embrasures is governed by the contour of the proximating teeth. During mastication, food is

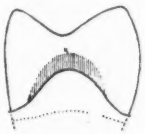


Fig. 1.—Diagrammatic representation of the area of liability to caries on the proximal surfaces of bicuspids and molars. The form of the arch varies greatly in different cases. (Figs. 1, 5-9 from Black's "Operative Dentistry.")

forced into the embrasures and the portions of the teeth forming the embrasures receive the scouring effect of food brushing across them. If the occlusion is not normal, the benefit of frictional cleaning by excursions of food will be lessened.

Our problem at this time is to apply these principles to bridge construction, in which a lost tooth is to be replaced by one of our own making, and not only new proximal contact but also embrasures and occlusion are to be supplied.

There appears to be a lack of understanding of the principles previously outlined; or it may be that there is a great deal of careless work being done. In either case, we see and hear of many failures due to recurrence or occurrence of decay around the margins of inlays used as bridge abutments.

In the preparation of a proximoclusal cavity for a bridge abutment, the proximal tooth having been extracted, the only guide to correct buccolingual width of the proximal portion of the cavity lies in the axial angles, near which the buccal and lingual margins of the cavity should be placed. But this does not assure the frictional cleaning of the margins of the inlay abutment by excursions of food. The thing that is important is so to construct the pontic that its proximal contour will be convex and round away from the inlay to the buccal and lingual

Fig. 2.—A fixed bridge replacing the upper second bicuspid; inlay abutments in the first molar and first bicuspid. The embrasures and the relation of the margins of the inlays to the pontic are to be noted. The extension of the cavity into the buccal groove of the first molar gives support to the inlay when tipping stress is brought to bear on the buccal cusp of the pontic.

angles, so as to make, with the abutment tooth, embrasures that are sufficiently wide and deep to admit a considerable amount of food. That is, the abutment tooth and the pontic, in their proximal relation, form the buccal and lingual embrasures. If the proximal surface of the pontic is broad and flat, the embrasures will be narrow and shallow and the margins of the inlay abutment will be near, if not in actual contact with, the pontic. Such a condition predisposes to the occurrence of decay. If the embrasures are

sufficiently wide mesiodistally and deep enough buccolingually, and if normal occlusion is restored, food will be forced into the embrasures during mastication and the margins of the inlay will receive, through the excursions of food, the benefit of frictional cleaning, which serves to maintain the immunity of the abutment teeth. (Fig. 2.)

It has been shown by Black that the area of liability, on the proximal surface of a tooth, often crescentic, is influenced in its buccolingual dimension by the occlusogingival position of the contact point. If the contact point is on a level with the crest of the occlusal marginal ridge, less food will be admitted to the embrasures, and the area of liability will extend farther toward the axial angles of the tooth. If the contact point is about 1 mm. gingivally of the crest of the occlusal marginal ridge, and the proximal surfaces of the proximating teeth slope properly toward the contact point, more food will be admitted to the embrasures, and the area of liability will be reduced in extent buccolingually. (Fig. 3.) In bridgework, the pontic replaces a missing tooth, and it should make a soldered contact, with the inlay abutment, of approximately the same form as would have obtained in the original contact relation. Many inlay abutments have failed when the outline form of the cavity was satisfactory, but the contact relation with the pontic was not made in such a way as to insure a scouring of the inlay margins during mastication. (Fig. 4.)

The location of the gingival margin of the cavity should be given careful attention. In ordinary operative procedure, it is our aim, in practicing extension for prevention, to place the gingival margin underneath the healthy gum tissue when the tissue is in its normal position, or nearly so. In case the recession of the gingivae after the tooth extraction is not excessive, it is a good plan to extend the

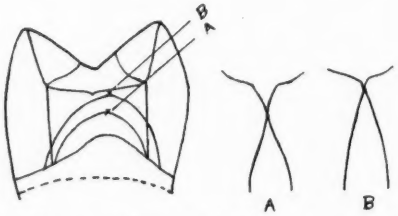


Fig. 3.—Diagrammatic representation of the proximal surface of a tooth on which has been drawn the outline form of a proximoclusal cavity. *A* and *B* represent two contact points. Rounding away from these points toward the buccal and lingual angles, the curved lines bound the area of liability. (Compare Fig. 1.) When the contact point is at *B*, the area of liability extends beyond the cavity outline. When the contact point is at *A*, the area of liability falls entirely within the cavity outline. At the right is the buccal view of the two contact points.

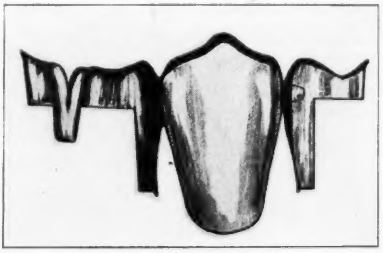


Fig. 4.—Buccal view of the bridge presented in Figure 2. This shows the slope from the marginal ridges to the contact points, which makes the abutment teeth less liable to decay in the future than they would be if the contact points were at the crest of the marginal ridges as shown at *B* in Figure 3. The wide interproximal spaces between the pontic and the abutments are also shown. The gingival margins of the inlays are not in "near" contact with the pontic.

cavity farther toward the gingival line than would be considered necessary in the usual operative procedure, in order that the gingival margin of the abutment may be placed under the gingivae, where caries is less likely to occur. Frequently, after the extraction of a tooth, the gingivae recede to such an extent that an attempt to place the cavity margin beneath would carry the gingival margin to the gingival line or farther. In such a case, good judgment dictates that the extension gingivally be just sufficient to make possible an interproximal space of good proportions between the abutment tooth and the pontic, so that the gingival margin of the abutment will not be in contact, or near contact, with the pontic. The interproximal space must be wide enough to permit easy cleansing by the free washing of saliva and by artificial means. (Fig. 4.)

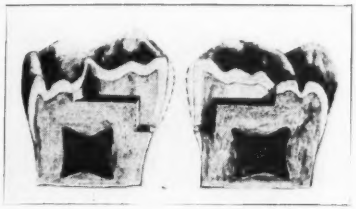


Fig. 5.—Split cavity showing the flat pulpal and gingival walls cut to definite angles with the surrounding walls for resistance form.

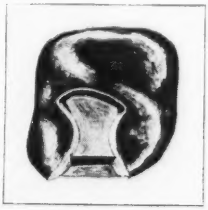


Fig. 6.—Occlusal view of a proximoclusal cavity, showing the definite dovetail for retention.

Extension for prevention has come to be an accepted principle in operative dentistry and is practiced by progressive dentists throughout the world. But there are still those who maintain that this principle should be applied only when making restorations for carious teeth. The thought in the minds of this minority is that if a tooth is sound, if it has not been attacked by caries, extension for prevention is out of place. It is argued that the extension of the cavity outline is to prevent recurrence of decay and not occurrence of decay. Therefore, the principle need not be applied to bridgework in case the abutment teeth are not carious.

This idea appears to be illogical and untenable. The line of junction of an inlay with a tooth is a vulnerable line and some point, or points, on this line may be the beginning place of decay on

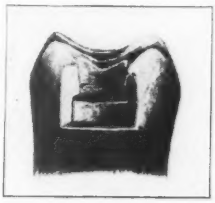


Fig. 7.—Proximal view of the proximoclusal cavity shown in Figure 6.

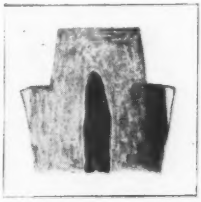


Fig. 8.—Sectional view of a mesioclusodistal cavity, showing the two axial walls converging gingivoclusally.

the tooth if the patient is susceptible to decay and if that margin is in a position where it might be covered by a colony of acid-forming bacteria, as it would be if it were in contact, or near contact, with a proximal tooth or a bridge pontic. Some people appear to be so perfectly immune to decay that caries would be unlikely to occur even if extension for prevention were disregarded, but there are few such. Even they may become susceptible, as immunity is not always permanent. It should be borne in mind that many people who are virtually immune to incipient decay may be sufficiently susceptible for decay to occur when conditions such as have been mentioned are present. These conditions are favorable for the action of the causes of decay and should be avoided whenever possible.

Fig. 9.—Occlusal view of a mesioclusodistal cavity as prepared for a gold inlay. All line angles and point angles are visible.

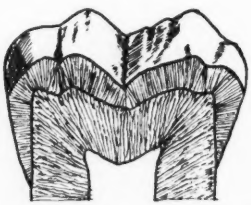


Fig. 10.—Buccal view of a lower molar split mesiodistally. (Figures 10-19, modified from figures in Black's "Operative Dentistry," show the technic for preparing a mesioclusodistal cavity in a sound molar tooth.)

RESISTANCE FORM

"Resistance form is that shape given to a cavity intended to afford such a seat for the filling as will best enable it to withstand the stress brought upon it in mastication."[1] There is greater demand for resistance form in bridgework than in cavity preparation for the usual operative procedures. The pontic may be equal in width to the abutment tooth, buccolingually, and therefore may bring much greater tipping stress on the abutment than would be possible when it is

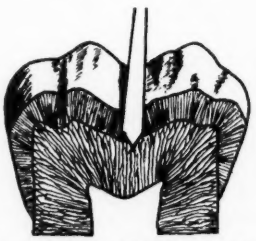


Fig. 11.—Bibeveled drill in position to make the initial cut in the central pit of the central fossa. The drill is adjusted to the engine handpiece and is used to penetrate the enamel and just reach the dentin.

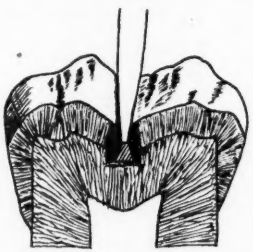


Fig. 12.—Inverted cone bur No. 35, new, is used to make the first cuts in the occlusal step.

1. Black's Operative Dentistry, Vol. II, p. 112.

in direct occlusion with its antagonist. (Fig. 2.) This makes necessary fairly broad, flat seats, cut at right angles with the stress of occlusion and at definite angles with the surrounding walls of the cavity. (Fig. 5.)

In the three-quarter crown, much the same effect may be had by making certain line angles sharp or at least well defined. The axial line angles in the case of the cuspid or incisor, and the proximoclusal line angles also in case of the bicuspid or molar, should be planed to definite form so that the abutment will rest securely on the tooth and will not move when subjected to the stress of mastication, even prior to cementation of the bridge. When this principle is applied, much difficulty in retention may be obviated.

RETENTION FORM

Inlays that are made to fit teeth which have been prepared with ample resistance form will hold well when definitely interlocked with the tooth. In case of the proximoclusal inlay, the dovetailed retention form should extend into the appropriate developmental grooves toward the buccal and lingual margins and the cavity should be cut through the enamel and into the dentin to a depth of about 1 mm. (Fig. 6.) Opposing walls should be as nearly parallel occluso-

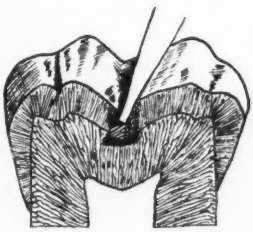


Fig. 13.—Inverted cone bur in position to extend the cavity distally. It is pressed toward the distal aspect and lifted occlusally in a series of cuts.

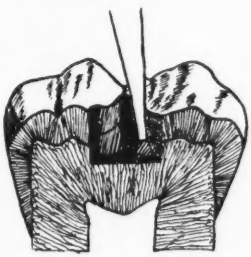


Fig. 14.—Making the extension to the mesial. A contra-angle hand piece should be used in order to give the bur the correct inclination.

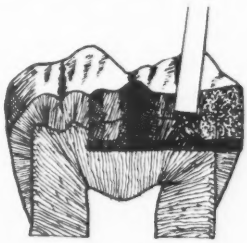


Fig. 15.—Widening the slot made by the inverted cone bur and removing undercuts. The chisel or enamel hatchet is used.

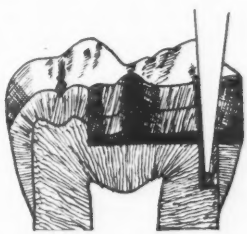


Fig. 16.—Extension gingivally made by engaging the dentin with inverted cone bur No. 34 just inside the dentino-enamel junction. By swaying the handpiece buccally and lingually, a groove is cut in the dentin to the depth desired. The enamel may be allowed to stand until this cut has been made as it acts as a guard for the bur.

gingivally and occlusopulpally as is consistent with good convenience form. (Fig. 7.)

The three-quarter crown has been demonstrated so frequently that it seems unnecessary to go into detail in discussing it. Suffice it to say that the mesial and distal grooves in this preparation should parallel the long labial or buccal slope of the tooth. This gives a much longer groove than would be obtained by making these grooves parallel with the long axis of the tooth, and therefore affords much greater retention.

Retention of inlay abutments by the use of pins in lieu of the three-quarter crown is being advocated, and there is no question that some men are getting splendid results by this means. It seems to me that this type of preparation is useful in a comparatively small number of cases and in the hands of a few men who, perhaps, are peculiarly fitted for this work. Most of us will do better to adhere to the simpler preparations, which have proved to be useful, and, for the most part, easier.

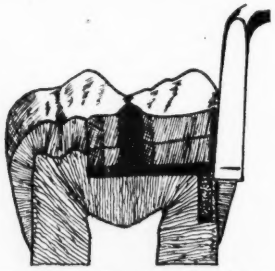


Fig. 17.—Removing the undermined enamel as left by the inverted cone bur (Fig. 16) and flattening the gingival wall. Enamel hatchets are used for this purpose.

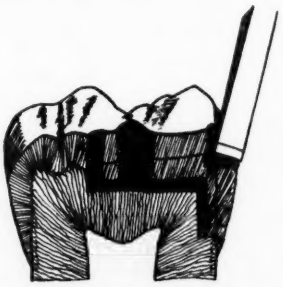


Fig. 18.—Extending the buccal and lingual walls buccally and lingually, for which the chisel or enamel hatchet is used. These instruments are also used to plane all enamel and dentin walls smooth.

CONVENIENCE FORM

Convenience form is the form given the cavity which will permit a wax pattern to be shed or withdrawn, without distortion or breaking. In the preparation of cavities for inlays, this step is the most important if we have in mind only the making of an inlay that fits the cavity. The outline form, resistance form and retention form may be prepared correctly; but if the convenience form is not well done, the inlay will not fit and the result will be failure. After many years' experience in teaching gold inlay technic to postgraduate students, I have concluded that a lack of appreciation of the requirements for convenience form is responsible for more failures in fit than any other single factor. Of course, undercuts must be removed either by planing or grinding or by filling with cement. But this is not sufficient. All surrounding walls should taper outward; or two opposing walls should diverge pulpoclusally or gingivoclusally.

This is still not enough. The axial walls in mesioclusodistal cavities and in three-quarter crowns should converge gingivoclusally. (Fig. 8.) Yet the cavity need not be hopper-shaped. A fair test is to make a critical visual examination with the mirror when the cavity is dry to see whether all the line angles and point angles may be seen simultaneously

from one point of view. This test does not always insure success, but if well done, it is very helpful and saves much time in making trial wax patterns. (Fig. 9.)

REMOVAL OF CARIOUS DENTIN

In preparing teeth for inlay bridge abutments, it is more than likely that there will be no caries remaining after completing the several steps previously described. But if there is any caries remaining, it should be thoroughly removed. In some cases, it is a good plan to remove remaining caries before completing the convenience form, as the removal of this softened material would necessitate a reconditioning of the cavity to comply with the requirements of convenience form.

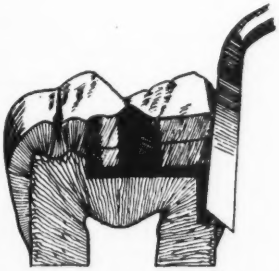


Fig. 19.—The gingival margin trimmers 15 (80)-8-12, right and left, beveling the cavosurface angle.

PLANING THE ENAMEL WALL AND BEVELING THE CAVOSURFACE ANGLE

The important step of planing the enamel wall and beveling the cavosurface angle is closely linked up with convenience form. In giving the necessary taper to the surrounding cavity walls, both the dentin and enamel walls should be planed smooth. Frequently, the inclination of the wall will be the same in both the dentin and the enamel. This cutting of the enamel for convenience form usually results in the cutting off of the outer ends of the enamel rods and leaves a strong enamel wall, well supported by sound dentin. In the occlusal portion of proximoclusal cavities, a more definite bevel of the cavosurface angle seems unnecessary. The gingival margin should be trimmed and beveled with the gingival margin trimmers.

Because of the apparent unfamiliarity of so many dentists with the G. V. Black technic of cavity preparation, a series of illustrations of this technic as applied to a proximoclusal cavity in a sound molar tooth are shown.

DISCUSSION

Henry W. Gillett, New York City: Dr. Blackwell has adhered so closely to the orthodox as to leave few points in his text on which to hang a discussion. In general terms, there is little with which the conservative operator, interested in rendering the best possible service, can disagree. There are a few features on which slightly different slants may be presented that will be of value to the young and inquiring practitioner, whom we always need to keep in mind. In his expression concerning extension for prevention, Dr. Blackwell correctly says that it has nothing to do with the removal of carious enamel or carious dentin. This is a point that is not always clearly understood, especially by practitioners who have been trained to the view that no particle of sound tooth material, and especially of sound enamel, ought ever to be removed, if it is in any way reasonably possible to retain it. In approximoclusal cavities of small size, it frequently happens that considerable sound enamel is necessarily removed in carrying out adequately the generally approved principles of "extension for prevention." In medium-size and large cavities, it more often happens that the removal of caries means inclusion of so much enamel that there is no need for further extension, and, in these cases, extension for prevention plays no part. I am glad of the opportunity to add emphasis to Dr. Blackwell's position with

regard to care in the establishment of embrasures of correct size and form. It is quite true that carelessness in this important feature is altogether too common. The points which Dr. Blackwell has stated should be fundamentals in the education of every man attempting to do bridgework, and the latter should train himself and his technicians to keep them constantly in mind, so that they shall be adequately cared for in every case, regardless of whether the abutment tooth is carious or noncarjous. I am in accord with what has been said concerning resistance form, but the statements concerning the three-quarter crown strongly tempt me to commit the offense of not sticking to the subject, which is so common with discussers. I will content myself with saying that I gravely question the use of the three-quarter crown for patients under 50 years of age, unless on pulpless teeth; and while I am very glad to discuss the principles of cavity preparation for bridge abutments, my position concerning the use of fixed bridges is very conservative. During four decades of familiarity with that field, I have seen the practical equivalent of the factors now held to insure effective sanitation so often result in failure that it will not greatly surprise me to see history repeat itself in that respect. In my estimation, none of the factors now stressed as making the fixed bridge safe, adequately care for the interproximal tissues between any two united natural teeth, provided there is a pronounced tendency to deposit of sordes in the particular mouth under treatment. I am aware that I am off the subject, but I feel that this subject should never be discussed without so handling it that the young practitioner shall always realize that diagnosis of fundamental conditions and decision as to whether a fixed bridge is allowable because of those conditions must have precedence. Retention form, convenience form, outline form are so intermingled in the cavity preparation technic, which I endorse, that I shall speak of them all together. As many of you know, I have advocated and practiced for years the slice cavity preparation for which the late M. L. Rhein probably made the first public plea, and that I now advocate the later channel slice preparation. That method conserves sound tooth tissue as compared with the preparation which G. V. Black himself advocated, and in many instances, it conserves still more of it than the preparation now commonly taught as the G. V. Black preparation. The channel slice preparation adds greatly to retention values. Adequate study of the lines advocated will satisfy all of you that no violence is done to the principles so well laid down by G. V. Black. The fact that the channels cut off nutrition from parts of the tooth that are to be retained may very likely be referred to and the deduction drawn that those parts of the tooth are mechanically weakened because of being so cut off. Many years ago, Dr. Black demonstrated that it is the decomposition of the mouth fluids, and organic matter carried into the dentin of pulpless teeth by those fluids that causes the weakness and brittleness characteristic of discolored dentin, and that so long as such tissues retain approximately normal color, there is little or no loss of mechanical strength. All such dentin is completely protected from access of mouth fluids as soon as the inlays are set. No man has ever heard me advocate speed in dental operations, if it meant sacrifice of quality of service, but it happens to be a fact that the channel slice cavity preparation offers the trained operator opportunity for doing speedy work in his cavity preparation and, at the same time, rendering the highest class of service. With regard to the cavosurface angle, the slice cavity preparation here is of outstanding value. It automatically results in placing the inlay margin in such relation to the cavity margin that one of the serious hazards of inlay practice is completely eliminated. There seems to be little question that the procedure commonly known as burnishing of inlay margins, after they have been set, (a step for which I prefer to use the term "spinning") is practiced by a great majority of dental practitioners. With the butt joint preparation, or any of its modifications, except in the case of longer bevels than are commonly used, instrumentation calculated to modify the form of the margins of the cast inlay when seated in the cavity is a hazardous procedure because of almost certain injury to the enamel margin that must result. The slice cavity preparation eliminates this hazard, because it places the inlay margin on sound enamel rods so well supported by adjacent rods that no instrumentation an intelligent operator would be likely to use at that point can possibly crush or mar them. It is easy to understand the fact that the profession first thought of the cast gold

inlay in all its relations in the terms of the foil filling. It is not so easy to understand the persistence of that view. Its relations to opposing and adjoining teeth, and the relations of outline form, resistance form and general anchorage form are practically the same, and then a new factor enters, the relation to the details of cavity preparation concerned with the mechanical retention of the inlay in its seat. For that retention, cement is required. Hence, the correct view of the relations of the cast gold inlay to cavity preparation should be expressed in terms of plastic filling cavity preparation, except that no undercut retention forms interfering with introduction or removal of the inlay from its seat is permissible. The cement retention is substituted for that feature. No inlays are dislodged from cavities with correct resistance and retention form because of crushing or breakage of the underlying cement by direct stress impact, provided the gold alloy used for the casting is strong enough to insure against metal flow under the stress applied. If the stress causes stretching of the isthmus connecting the approximal and occlusal segments of an inlay, the cement bond will then be broken, and that isthmus of gold is the spot most needing to be safeguarded. Our most available safeguard is the step we all use to guard the same factor in the amalgam filling, that is, dovetail retention form calculated to resist displacement of the approximal portion of the inlay either mesially or distally. This means retention grooves in lateral walls with avoidance of any form locking the cavity impression, the wax pattern or the inlay against removal in an occlusal direction. Our cements are amply strong to resist normal strains tending to lift the inlay directly out occlusally, if the described mechanical retention is provided, and I am reliably advised that they can be made stronger if we demand it, and if the manufacturers make adequate use of the facilities of the Bureau of Standards. The cements we use in inlay work have no adhesion. They supply retention by mechanical interlocking with the inequalities of the cavity wall and the inlay surface. This factor is within the control of the operator. These principles, when applied to inlay cavity preparation, permit of elimination of the dangerous feature of very close contact of inlay and interior cavity walls, and the placing of as thick layers of cement between gold and pulp and gold and sensitive areas of dentin, as the resistance of the gold formulae used in the inlay allows. We are in greater need of exact data as to how hard and how resistant a gold we may safely use than we are of information as to many steps in inlay practice now absorbing an undue amount of research attention. When that one fact is available, it will exercise a controlling influence on cavity resistance and cavity retention form.

EXPERIMENTS ON DOGS, RABBITS AND RATS, AND INVESTIGATIONS ON MAN, WHICH INDICATE THE POWER OF CERTAIN FOOD FACTORS TO PREVENT AND CONTROL DENTAL DISEASES*

By MAY MELLANBY, London, England

THAT dental diseases are responsible for a vast amount of ill-health is generally recognized. The problem of the prevention of this great evil can be solved only by a patient search for the causes, and by the practical application of the knowledge acquired.

Dental caries has generally been thought to depend almost entirely on conditions external to the teeth: the possibility that there is a defensive mechanism in the dental structures, and that the body as a whole may play a part in these defensive processes has not hitherto received much attention. This attitude has arisen mainly from the work of Miller,[1] who formulated the well known chemicoparasitic theory. The simplicity of his teaching, together with the clear evidence that he adduced, convinced many people that here was a solution—a complete solution—of the problem of dental caries.

The prevention of dental disease has thus been regarded as a comparatively simple one, a matter largely of oral hygiene. The toothbrush, dentifrices of varied constitution, mouth washes, acid fruits, hard and fibrous foods, food containing but little "fermentable" carbohydrate and foods with so-called tooth cleaning properties have been advocated as preventives, and most of our propaganda has been based on the supposition that "a clean tooth cannot decay." Yet in spite of all the publicity given to these teachings, dental disease is so widespread that it is undoubtedly one of the outstanding problems of today.

It is difficult to imagine that this state of affairs is due merely to failure to apply Miller's doctrine. It seems more probable that the teaching of Miller and his followers is only part of the story, and that there are other factors which have not been taken into account. It is well known that some people with neglected mouths have teeth free from caries; whereas, others who take great care in matters of oral hygiene have extensive caries. In fact, the most rigid adherence to the commonly accepted rules of dental hygiene constitutes no safeguard against dental disease. It appears, then, that the prevailing teaching as to the etiology of dental caries is inadequate and that the whole subject demands investigation from a new point of view.

Although the immediate cause of dental caries is the action of bacteria, the work discussed in this paper suggests that

*Read before the Section on Histology, Physiology, Pathology, Bacteriology and Chemistry (Research) at the Seventy-First Annual Session of the American Dental Association, Washington, D. C., Oct. 8, 1929.

1. Miller: Micro-Organisms of the Human Mouth, 1890.

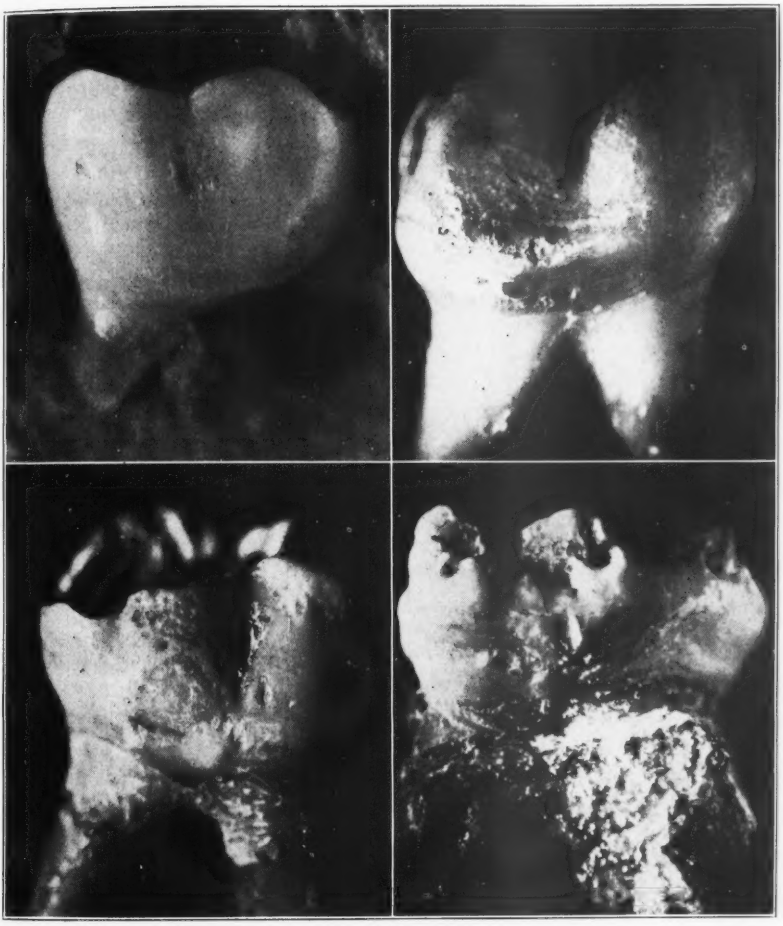


Fig. 1.—Views of the enamel surface of deciduous second molars taken with an oblique light to show degrees of surface roughness (hypoplasia). Above: Left: Nearly normal surface; slight hypoplasia. (Compare Fig. 2, above, left.) Right: Surface showing general roughness; hypoplasia. (Compare Fig. 2 above, right.) Below: Left: Very rough surface; severe hypoplasia. (Compare Fig. 2, below, left.) Right: Deficient enamel; "gross" hypoplasia. (Compare Fig. 2, below, right.)

the practical solution of the problem, as in the case of many other bacterial invasions, is to be sought not so much in the attempt to eliminate environmental conditions favorable to infection as in the establishment of resistance in dental tissues and in the body as a whole. The teeth and the gingival and periodontal tissues are living structures, vital organs of the body, and, like other organs, are

capable of offering a high or low resistance to bacterial invasion under varying conditions. Great advances have been made during recent years in physical, chemical and biologic sciences, especially in relation to nutrition. Undoubtedly, these advances may have some bearing on the problems with which we are concerned.

The investigations to be described demonstrate that the minute structure of the developing tooth and the reaction of the developed tooth and attaching tissues to caries and periodontal diseases are influenced by the chemical nature of dietetic ingredients which, after being digested and absorbed, are carried in the blood stream to the tissues of the body and thus to the dental structures.

The biologic method of research involving animal experiments is now a general procedure in most branches of physiology and pathology, as it affords the necessary control of conditions for the study of certain problems. Indeed, in dietetic investigations, most of the recent advances in knowledge have resulted from the use of animals. For example, the discovery of the etiology of beriberi by Eijkman,[2] in 1897, resulted from experiments on birds; that of scurvy by Holst and Frohlich,[3] in 1912, from the use of guinea-pigs, and that of rickets by Edward Mellanby,[4] in 1917 and 1918, from his experiments on dogs.

It is only by such means that these advances in our knowledge have been made possible, for, apart from other difficulties, the great complexity of foodstuffs renders it almost impossible to make accurate deductions as to the relation of cause and effect when initial observations are made on man. With animals, it is possible to choose one particular dietetic factor at a time and, by varying it, to track down and determine what structure or function is specially influenced by it. By such means, not only has it been possible to establish the relationship between specific defects of diet and certain disorders, but also to prove the existence, previously unsuspected, of the vitamins, without which, as shown by Sir Frederick Gowland Hopkins,[5] in 1912, life is impossible.

The investigation to be described began in 1917 and had its origin in my husband's work on the subject of rickets, started two years earlier, and, in many cases, the same animals were used for both purposes.

The domestic dog was used in the majority of the experiments because it has a metabolism somewhat similar to that of man. Like man, the domestic dog is omnivorous, and it has the great advantage of being able to live as a member of a family under the same hygienic conditions. It can also readily be kept in excellent health under laboratory conditions as long as desired, at any rate up to eight years. Moreover, the structural defects found in the dog's teeth under experimental conditions are, on the whole, similar to those found so commonly in man. Any possibility that the factors controlling the structure of the dog's teeth stand in a category by themselves has been excluded by an extension of the experiments to rabbits and rats and, on a small scale, to human beings, the results obtained being in all cases closely comparable to those previously found with dogs.

2. Eijkman: Arch. f. path. anat., 149:187, 1897.

3. Holst and Frohlich: Ztschr. f. Hyg. u. Infectionskrankh. 72:1, 1912.

4. Medical Research Council Report, 1916-1917, p. 28. Mellanby, Edward: J. Physiol., 52:11, 1918; ibid., 52: 53, 1918.

5. Hopkins, F. G.: J. Physiol., 44:425, 1912.

Experimental work on puppies and other animals demonstrated that animals living under conditions which are almost identical, with the exception of small differences in diet, developed great variations in the structure of teeth, jaws and related tissues. Ultimately, any degree of imperfection could be produced at will. Moreover, as the work progressed, evidence accumulated which suggested that the presence in or absence from the diet of certain ingredients influenced not only their development, but also their power of resistance after eruption, as measured by their reaction to harmful stimuli. These experimental results gave a strong indication that, for the adequate study of the causes of dental disease, the metabolic conditions influencing the development of the teeth and

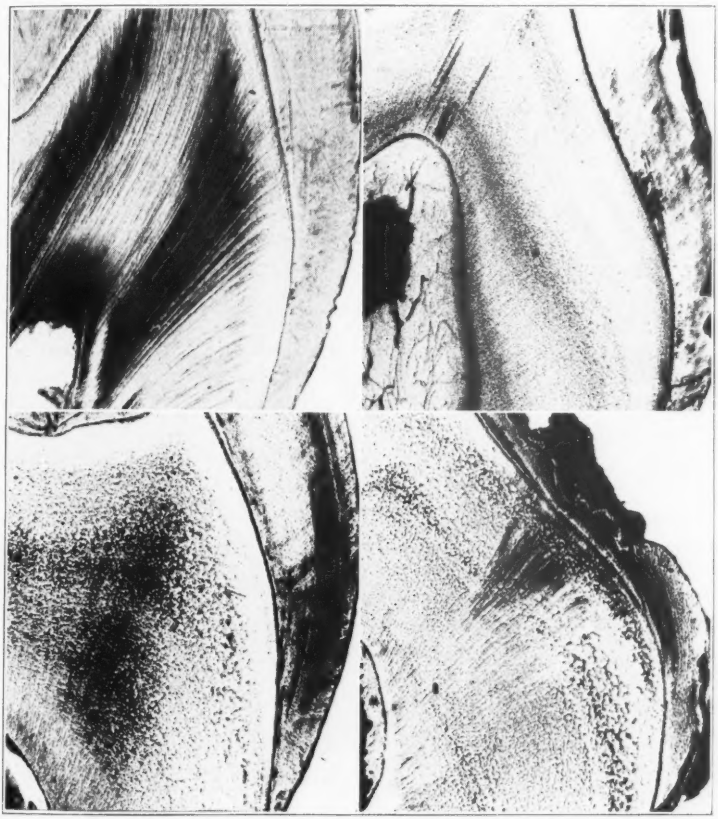


Fig. 2.—Sections of deciduous second molars shown in Figure 1. Above: Left: Slight hypoplasia. Right: Hypoplasia. Below: Left: Severe hypoplasia. Right: "Gross" hypoplasia. The interglobular spaces are arranged in Owen's lines. (Reduced one-third from a magnification of 30 diameters.)

periodontal tissues must be taken into account. Their significance in connection with human beings can be established only by further tests on man himself, and the conditions under which these tests can be made are very different from those under which animal tests are carried out in the laboratory. For instance, control of diet is usually only possible to a limited extent, chiefly because it is almost an impossibility to give the same diet to human beings day after day for an extensive period. Nevertheless, I have obtained very suggestive information by the following methods:

1. Attempts have been made to produce perfectly formed teeth in a number of children by inducing their parents to feed them in the way suggested by the animal experiments as being the most likely to lead to this result. Although the efforts are promising, a prolonged investigation on these lines, with full control, is yet required.

2. With the object of determining the frequency with which structural defects are present in the teeth of children, and the association or otherwise of such defects with dental disease, careful macroscopic and microscopic examination has been made of a large number of children's teeth.

3. In order to study the defensive reaction to harmful stimuli (caries) in teeth already fully formed and erupted, an investigation was planned and carried out in conjunction with Dr. C. Lee Pattison and Mr. J. W. Proud, L.D.S.[6] Children in an institution were divided into groups and were fed on diets which, while similar in respect to most of the ingredients, differed as regards those properties which play an important part in the calcification of the teeth and jaws, as had been found in animal experiments. Great differences in the rate of development and spread of caries resulted.

As far as they go, the results of the observations made on human beings seem to be in harmony with animal experimentation. They support the hypothesis that the structure of the tooth is an important factor in the causation of dental caries in human beings, and that those dietetic factors which result in the formation of normal or hypoplastic, i. e. poorly calcified, teeth, also alter the resistance of the erupted teeth to harmful influences by increasing or decreasing their defensive powers. The evidence suggests the possibility that perfect teeth and jaws may be deliberately produced in man by suitable diets during the period of their development and that similar diets may confer on fully erupted teeth an increased resistance to infective and other harmful processes.

I propose in the following remarks to mention first the human investigations and in this way to prevent the problems which the animal results, discussed later, help to solve.

PERFECT AND IMPERFECT OR HYPOPLASTIC TEETH

The adoption by different investigators of different standards of normality has led to differences of opinion as to the extent to which defects commonly exist. For this reason, I will describe, as far as possible, what I mean by perfect and imperfect, defective or hypoplastic structure, and discuss the use of the term "normal" as applied to the structure of teeth.

It will be generally agreed that there is an ideal structure of the enamel and

6. Mellanby, May; Pattison, C. L., and Proud, J. W.: Brit. M. J., 2, 354 (Aug. 30) 1924; Mellanby, May, and Pattison, C. L.: Brit. Dent. J., 47:1045 (Oct. 1) 1926; Brit. M. J., 2:1079 (Dec. 15) 1928.

dentin, as of other tissues of the body. The enamel is a hard, brittle and semi-translucent substance, which, to the naked eye, has a smooth, lustrous and whitish appearance. Histologically, it is noncellular and is built up of prisms united by densely calcified intermediate substance. It shows little or no pigmentation under the microscope. The dentin is a yellowish white, translucent substance which microscopically consists of a noncellular homogeneous material traversed regularly by branched dentinal tubes which contain organic matter.

Only very obvious abnormalities of structure have as a rule been described in dental literature as defects. These gross defects, which include pits and grooves in the enamel or the entire absence of enamel over certain areas, have been designated as hypoplasia and are said to occur in about 2.5 per cent of deciduous and about 10 per cent of permanent teeth. Sections of such teeth

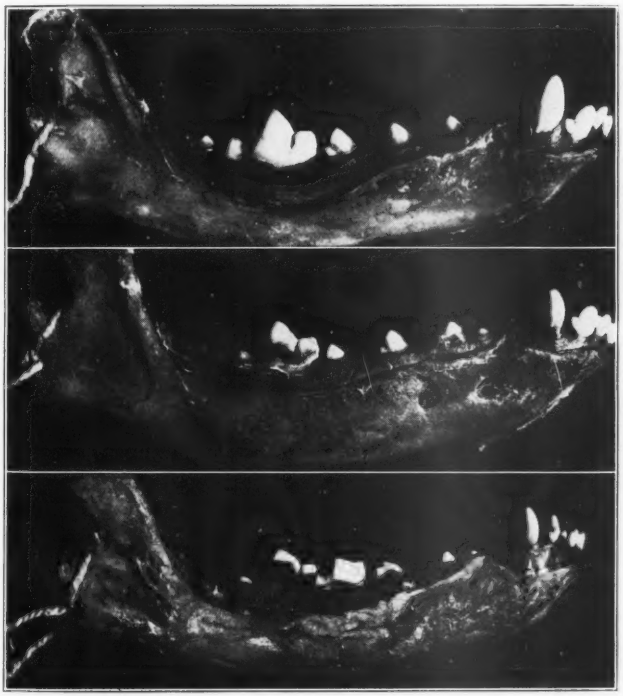


Fig. 3.—Mandibles of three puppies of the same litter, showing the effect of varying the fat of the diet. The basal diet was the same in each case, and the diet variants were as follows: Above: Cod-liver oil. The teeth are white and glistening. Center: Linseed oil. There is some pigmented enamel, and eruption was delayed. Below: Palm kernel oil. The enamel is very pigmented and rough, and eruption was greatly delayed.

usually show deeply pigmented lines in the enamel, known as brown striae of Retzius, and corresponding rows of interglobular spaces in the dentin, often called Owen's lines. These "spaces," obviously defects, are actually areas of uncalcified matrix, as will be seen below.

In young growing teeth, there is always a portion of uncalcified matrix—the odontogenetic zone—bordering on the pulp and penetrated by the processes of the odontoblasts. In this layer, the deposition of lime salts occurs in the first place in the form of rounded masses or calcospherites. The odontogenetic zone in a well calcified tooth is thin, for the calcospherites coalesce soon after being deposited, forming a more or less homogeneous structure; but when calcification is imperfect, the odontogenetic zone is wide and irregular, and the calcospherites do not coalesce, which leaves areas of uncalcified matrix, which are known as interglobular spaces. In general, it may be said that defects corresponding in time of development to the defects of the dentin are found in the enamel which is calcified at the same time.

In using the word "hypoplasia," I have included all these defects in macroscopic and microscopic appearance and have not limited it simply to those defects so readily seen with the naked eye. Teeth showing "gross" hypoplasia, indeed, often have fewer defects of dentinal structure than teeth with no such obvious external defects.

I have found in the teeth that I have examined all grades of imperfect structure, one grade merging into the next; but to simplify classification, I have divided the defects into three groups: slight hypoplasia, hypoplasia and severe hypoplasia (including "gross" hypoplasia). The teeth not classified under one of these headings were considered as perfect or normal in structure, the term "normal" thus indicating a well-calcified tooth in which the enamel is smooth and little pigmented, and the dentin free from interglobular spaces when examined under the microscope.

It will be seen that the term is not used to denote that type of structure most commonly found in human teeth. Since interglobular spaces in human teeth have been shown to be so general, some dental authorities have suggested that they are not an indication of a defect. On the other hand, if it is agreed that gross departures from the ideal structure of enamel and dentin constitute defects and that slight departures differ in degree only, and not in kind, it must surely be admitted that any such departure from the standard of perfection constitutes in essence a defect, though it may be considered as of so slight a nature as to have little or no practical significance. For the moment, the practical significance is of no concern, but the term "defect" or "hypoplasia" has been used to indicate any departure from the ideal structure. This point of view is supported by the fact that although the ideal structure is relatively uncommon, it can be readily produced in experimental animals, as can also varying degrees of structural defect similar to those seen in human teeth. (Figs. 1 and 2.)

The teeth which formed the material for this investigation were obtained from various sources, and included the exfoliated and extracted teeth of the children of friends, teeth supplied to me by dental surgeons in private or hospital practice and by school dentists, and teeth from children in an institution, on some of whom the effect of various diets was being tested. In some cases, the dental surgeons providing the teeth stated whether

they were normal or hypoplastic in structure on the basis of the standards in general use. Between 2 and 3 per cent were said to be hypoplastic.

In many cases, it was possible to examine the teeth in the mouth before extraction, in the hand after shedding or extraction and finally under the microscope. The correlation of the results obtained by these methods will be discussed later. The teeth were usually placed in 10 per cent formalin (solution of formaldehyd) saline and forwarded to me for examination. Sometimes notes relating to the health and environment of the children were supplied. Diagrams and notes were made of the appearance of the teeth and of the amount of caries seen superficially. Slices were cut with a fret-saw and further notes taken. Ground sections were then prepared by a modification of Weil's process.

TABLE I.—MICROSCOPIC STRUCTURE OF 1,306 DECIDUOUS TEETH

	Total Number Examined	Normal		Slight Hypoplasia		Hypoplasia		Severe Hypoplasia	
		Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Incisors, upper	161	78	48.4	55	34.2	18	11.1	10	6.3
Incisors, lower	75	37	49.3	32	42.7	4	5.3	2	2.7
Cuspids, upper	98	9	9.2	31	31.6	28	28.6	30	30.6
Cuspids, lower	58	3	5.2	28	48.3	15	25.7	12	20.8
Molars, first upper	128	12	9.3	28	21.9	40	31.3	48	37.5
Molars, first lower	121	5	4.3	21	17.3	50	41.3	45	37.1
Molars, second upper	196	2	1.0	18	9.2	53	27.0	123	62.8
Molars, second lower	199	3	1.5	9	4.5	48	24.2	139	69.8
Total	1,036	149	14.4	222	21.4	256	24.7	409	39.5

THE STRUCTURE OF HUMAN DECIDUOUS TEETH

As the result of examining large numbers of deciduous teeth, primarily of English children but also of children of other nationalities, I am convinced that the majority of the deciduous, and probably also the permanent, teeth met with in civilized countries are defective in structure.

As seen in Table I, only 14.5 per cent of 1,036 teeth examined microscopically were perfect, and 21 per cent slightly hypoplastic in structure. The incidence and position of defects in the different types of teeth show that, on the whole, the earlier the calcification, the better the structure. For example, the incisors, which calcify before the molars, are usually far better formed than the molars, 49 per cent of the incisors being normal in structure as against 3.4 per cent of the molars. Moreover, any defects in the incisors are usually found in the later formed enamel and dentin only; whereas, such defects are also common in the earlier formed enamel and dentin of the molars.

Hypoplasia of the previously recognized types, referred to in this communi-

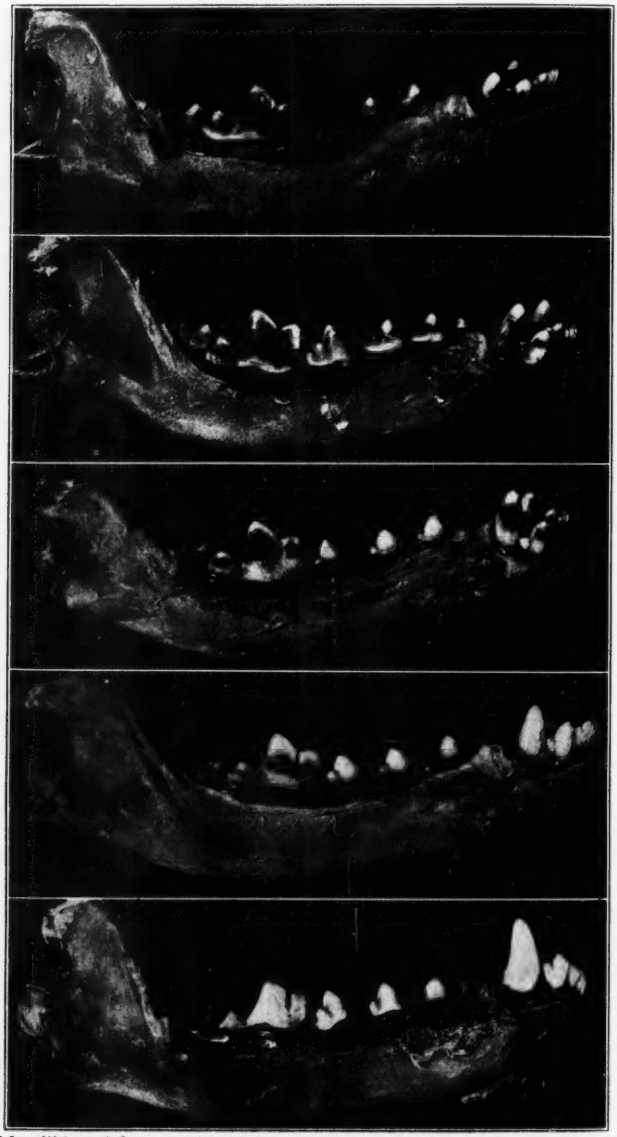


Fig. 4.—Mandibles of five puppies of the same litter. The basal diet was the same in each case. The variants in diets, reading from top to bottom, were: olive oil; olive oil and monosodium acid phosphate; olive oil and tricalcic phosphate; olive oil and calcium carbonate; cod-liver oil. As regards the degrees of pigmentation of the enamel and of eruption of the teeth, the mandible shown at the bottom is perfect and the one just above it is the next best.

cation as "gross" hypoplasia, was seen in only about 3 per cent of the teeth.

The question naturally arose as to whether defects in the teeth which were obvious microscopically could be detected by examination of the surface enamel while still in the mouth. The possibility of detecting defects in the enamel surface of exfoliated or extracted teeth by a graphite method was shown some years ago by Pickerill,[7] who found that a common abnormality of the enamel of the teeth of civilized people was the presence of well-defined horizontal ridges and furrows, the so-called imbrication lines. In the teeth of native races living under their natural conditions, these lines were far less distinct.

The method that I adopted for the purpose of examining the macroscopic structure of teeth in the mouth and in the hand, after they had been exfoliated or extracted, was as follows: a somewhat blunt probe was rubbed over the tooth, especially over the labial or buccal surface. This gave an indication of the "roughness" of the enamel. The degree of roughness was used as the main guide as to the structure of the tooth. The discoloration of the enamel, whether general or in patches, opaque areas, the dullness or lack of luster, as well as the presence of deep pits or grooves, or the absence of enamel, were also taken into account. Macroscopic examination by these methods revealed, in a large number of cases, abnormalities in all or part of the enamel surface, the significance of which depended on their association with microscopic defects of the underlying enamel and dentin. Imbrication lines are not usually so easy to distinguish in the deciduous as they are in the permanent teeth, even by the graphite method.

Table 2.—Relation of Structure and Caries

	Total Number	Normal Structure or Slight Hypoplasia		Hypoplasia or Severe Hypoplasia	
		No Caries or Slight Caries	Caries or Severe Caries	No Caries or Slight Caries	Caries or Severe Caries
Incisors	236	172	30	15	19
Cuspids	156	56	15	29	56
Molars, first	249	31	36	14	168
Molars, second	395	11	21	40	323
Totals	1,036	270	102	98	566

It was found that a close correspondence was obtained when teeth were examined (1) macroscopically while in the mouth, and while in the hand after being exfoliated or extracted, and (2) microscopically. After examination of the same teeth macroscopically in the mouth, and at a later period in the hand, close agreement was obtained in more than 85 per cent of the cases. Even when differences in the reports occurred, they were not usually great. Again, more

7. Pickerill, H. P.: Prevention of Dental Caries and Oral Sepsis: London, 1912.

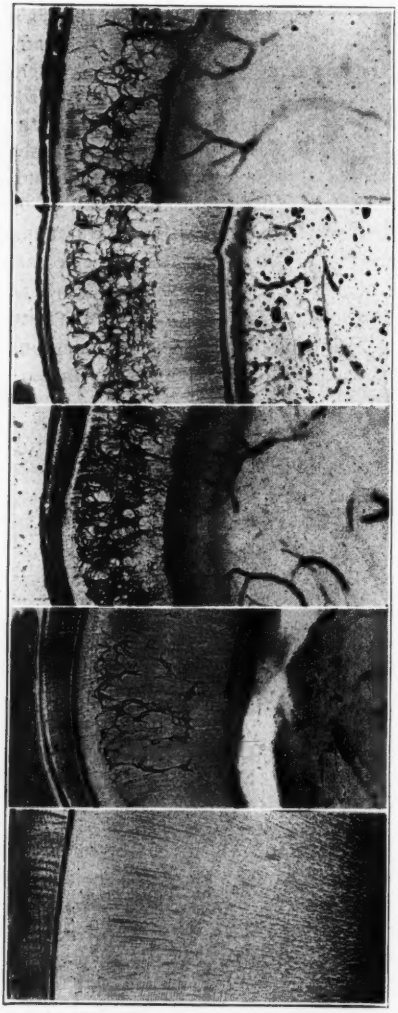


Fig. 5.—Sections of the carnassials from the jaws shown in Figure 4. The variants in diets, reading from top to bottom, were: olive oil; olive oil and monosodium acid phosphate (during the last month, cod-liver oil replaced the olive oil in order to keep the animal alive; the thickness of normal dentin laid down during this period should be noted); olive oil and tricalcic phosphate; olive oil and calcium carbonate; cod-liver oil. There is a difference in thickness of enamel and dentin and in the number of interglobular spaces in each case. Only the last (bottom) section is perfect in structure. (Reduced one-third from a magnification of 40 diameters.)

than 85 per cent of the microscopic examinations were in close agreement with the results of macroscopic examination.

STRUCTURE OF HUMAN TEETH IN RELATION TO CARIES

In the teeth examined as to structure, referred to above, the extent of caries was also noted, and it was found that there was an intimate relationship between structure and caries. Of the 1,036 deciduous teeth, 36 per cent were perfect or only slightly hypoplastic in structure, and of these, 73 per cent were free from carious cavities. On the other hand, of the 64 per cent which were hypoplastic, only 15 per cent were free from carious cavities, the majority of the others having large cavities. The incisors were better calcified than any other type of tooth, and were also much less susceptible to caries. The degree of caries in a tooth is generally proportional to its structural defects; i. e., slight caries is found in a well-calcified tooth, extensive caries in a badly calcified tooth. (Table 2.)

It will be evident from the results summarized above that two main practical problems are presented:

1. If human deciduous teeth in this country are so badly calcified as the investigations recorded suggest, what is the cause of this maldevelopment or hypoplasia?

2. Why is the relationship between the structure of teeth and the incidence of caries not absolute? Is it partly because fully erupted teeth, whatever their structure, have some power of altering their resistance to caries, and if so, what is the

mechanism which controls this resistance?

I shall deal now with the first of these problems and describe the factors of diet and environment in the production of well and badly calcified teeth as revealed by animal experiments and to some extent confirmed by investigations on children. Afterwards, I shall discuss the question of the resistance of teeth to caries independently of their structure.

SOME FACTORS OF DIET AND ENVIRONMENT INFLUENCING THE CALCIFICATION OF TEETH

My work on calcification of the teeth, first published in 1918, is, as mentioned before, an outcome of my husband's investigations on rickets, and our work in collaboration has shown that, at least in dogs, the conditions responsible for the bony changes in rickets are also responsible for defects in the structure and arrangement of the teeth. Evidence is accumulating which suggests that the same is the case in children. As stated above, the majority of children's teeth are defectively calcified, and most of these sooner or later became carious. Incipient rickets is probably also far more common than is usually recognized. McGonigle, following up the work of MacIntosh, found that of more than 2,500 school children in County Durham, 83 per cent had definite rickets. Of the group with definite rickets, only 9 per cent had teeth free from caries; whereas, 73 per cent of the children with no rickets had caries-free mouths.

There is no need here to give details of the experimental methods used, except to say that the animals were all kept as far as possible under the same hygienic conditions, unless otherwise mentioned. In comparing two or more diets, puppies of one litter were used, and, in comparative experiments, only one factor was varied at a time. The puppies were put on a diet at the same time and killed at the same time. A typical basal diet is as follows: cereal, from 80 to 200 gm.; lean meat, from 10 to 30 gm.; separated milk, from 150 to 250 c.c.; fat, 10 gm.; orange juice (for vitamin C); yeast (for vitamin B_1 and B_2); sodium chlorid, from 1 to 4 gm. The amount of food given to the individuals of a family was usually regulated by the amount eaten daily by the puppy with the smallest appetite. If one puppy left some food, the amount of food given to the rest of the family was generally reduced.

Apart from any fat-soluble vitamins A and D that may be present in the fat given, it will be seen that the basal diet is deficient in this respect, but that otherwise it contains a good supply of energy-bearing foods (proteins, carbohydrates and fats) and of salts. A few years ago, whatever variety of fat had been used, it would have been called a very satisfactory diet.

The experiments have shown that some foods contain substances with a specific influence on the calcification of the teeth and jaws, and that certain environmental conditions may also be involved.

Factors assisting calcification are: (1) the use of A vitamin, the antirachitic or calcifying vitamin D, having a distribution and properties similar in many respects to vitamin A, and which until recently has often been referred to as vitamin A; (2) the use of calcium and phosphorus; (3) the exposure of the skin or of certain foodstuffs in the diet to a source of ultraviolet radiation such as sunlight or a mercury-vapour lamp.

The factor interfering with calcification is the use of a substance or substances associated especially with cereals and cereal products.

FACTORS IN CALCIFICATION OF TEETH

1. *Vitamin D.*—The most potent factor in promoting the development of normal teeth and jaws is a vitamin associated in general with fats and now called vitamin D (the calcifying or antirachitic vitamin). In distribution and properties, vitamin D in many ways resembles vitamin A. Like this vitamin, it is found in cod-liver oil, most fish oils that we have tested, egg yolk, whole milk, suet and butter. The potency of any one of these substances differs under varying conditions. For instance, summer butter is more potent than winter butter. The reason for this became obvious when the relation of ultraviolet radiation to vitamin D was known. The cow itself and the food on which it lives get more radiation from the sun during the summer than during the winter months. Vegetable oils, as they are usually prepared, have generally poor calcifying and growth promoting properties, while lean meat, cereals of all kinds, egg white, orange and lemon juice, yeast and most vegetables have little or none. Heating such

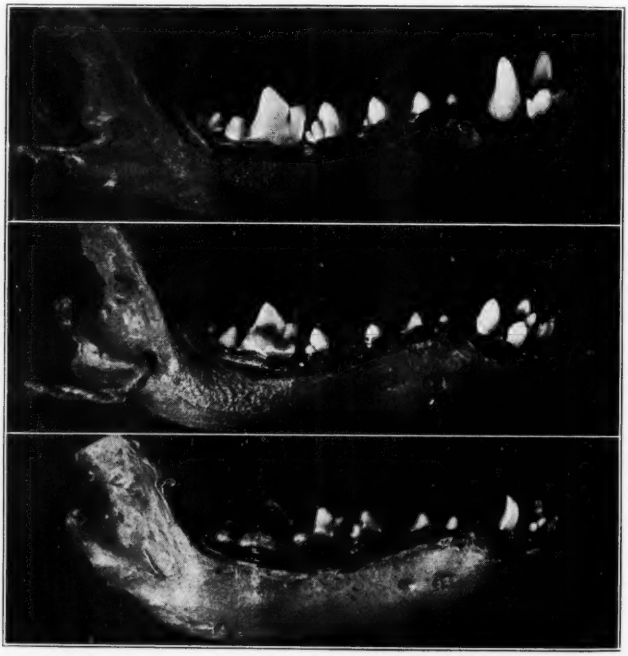


Fig. 6.—Mandibles of three puppies of the same litter, showing the effect of white flour versus oatmeal in the diet when there is a deficiency of vitamin D in the diet. The basal diet was the same in each case; the variants were as follows: above: cod-liver oil and oatmeal; center: linseed oil and the white flour; below: linseed oil and oatmeal. The structure of the teeth of the mandible shown below is very much worse than that of the mandible shown in the center.

fats as butter and cod-liver oil to 120 C. in the presence of oxygen ultimately destroys their power to promote calcification as well as growth. (Figs. 3-5.)

Experiments on rabbits[8] and rats confirm those on puppies. The basal diet used for rabbits was as a rule bran, oats and calcium carbonate. The addition of cod-liver oil or vitamin-containing extracts of cod-liver oil, egg yolk, milk and other vitamin D-containing substances resulted in normal calcification; whereas the use of substances lacking or relatively deficient in vitamin D, such as egg white and white turnip, resulted in hypoplastic teeth.

2. *The Presence of Calcium and Phosphorus.*—It is obvious that since teeth are largely made up of calcium and phosphorus, the calcification of teeth must depend on the presence in the diet of a sufficiency of these substances. The question is, what is a sufficiency? It is impossible to choose any ordinary diet which does not contain some calcium and phosphorus, but whereas phosphorus is fairly abundant in most diets, it is easily possible to cut down the calcium intake to a very low limit. Thus, the elimination from the diet of milk, egg yolk, cheese, cream and green vegetables will almost certainly result in a diet containing little calcium. That is to say, a diet made up of commonly eaten foods such as bread, rice, meat, jam, fruit and fat will contain little of this substance.

It is probably correct to sum up the significance of calcium and phosphorus in the diet, as far as teeth are concerned, as follows: The minimum quantity of calcium and phosphorus, especially the former, necessary for the formation of perfectly calcified teeth varies with the amount of vitamin D consumed. With a high vitamin D intake, there seems to be no danger in the case of ordinary diets that either calcium or phosphorus will be less than that required for perfect tooth calcification. Under ordinary conditions of diet, without extra vitamin D, it is easy for the diet to contain too little calcium for perfect tooth calcification. Further, no matter how high the calcium and phosphorus intake may be, unless there is also a sufficiency of vitamin D in the diet, the teeth will be defectively calcified. (Figs. 4 and 5.)

McCollum and his collaborators[10] and others using rats as the experimental animals have shown that the calcium-phosphorus ratio is of great significance in the production of rickets in these animals. Killick and I[8] found that diets which regularly produced defective structure of the bones and teeth of rabbits had a corresponding ratio roughly equal to that shown by McCollum and others to prevent rickets in rats.

3. *Effect of Exposure of the Skin or of Certain Foodstuffs in the Diet to Ultraviolet Radiation.*—As a direct outcome of the discovery of the antirachitic vitamin by Edward Mellanby, intensive work on the effect of diet on bone calcification in rats has been carried out during the past seven years, and, although the new knowledge gained has not influenced the central facts, it has extended and clarified the situation and emphasized the importance of the original discovery. In 1919, Huldschinsky[11] showed that when rachitic children are exposed to the radiations of a mercury-vapour lamp, the bones harden.

8. Mellanby, May, and Killick, E. M.: Biochem. J., 20:902, 1926.

10. McCollum, E. V.; Simmonds, Nina; Shipley, P. G., and Park, E. A.: J. Biol. Chem., 47: 507 (Aug.) 1921.

11. Huldschinsky, K.: Deutsch. Med. Wchnschr., 45:712, 1919.

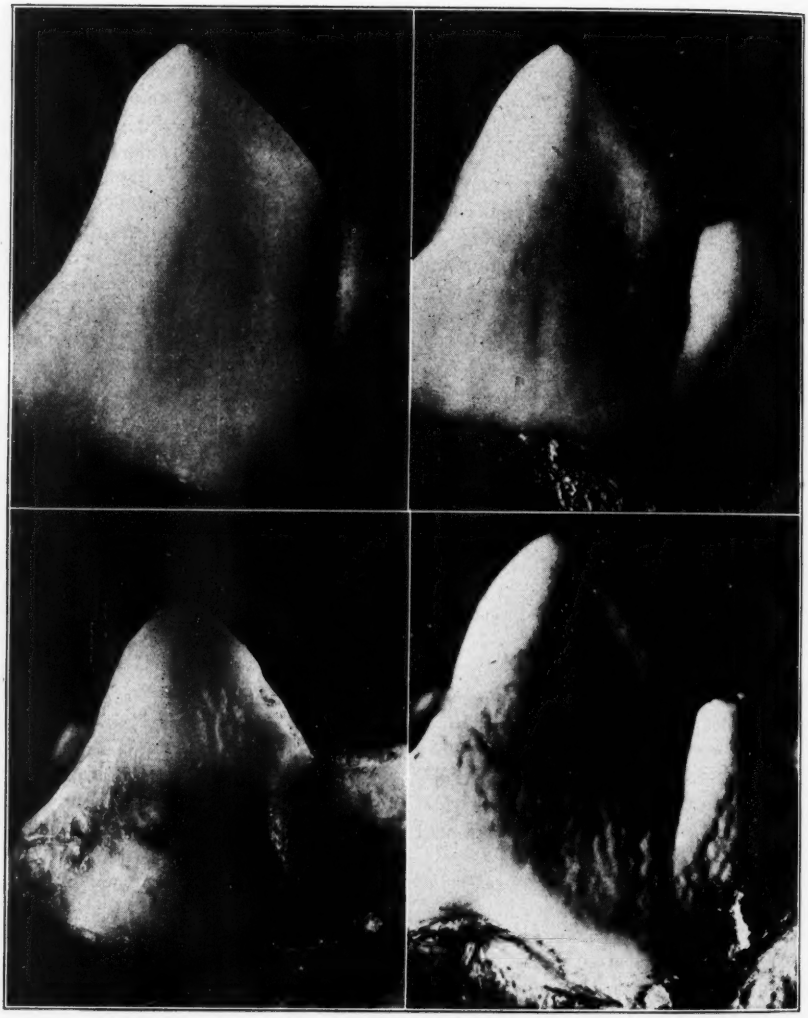


Fig. 7.—Four lower carnassials of puppies, taken with an oblique light to show some of the surface defects which can be obtained experimentally. Above: Left: Nearly normal surface. The diet was rich in vitamin D. Right: Slight hypoplasia. The diet was slightly deficient in vitamin D. Below: Left: Hypoplasia. The diet was deficient in vitamin D. Right: Severe hypoplasia. The diet was very deficient in vitamin D.

From that time onward, many investigators have attempted to correlate the two apparently unrelated facts, viz., the calcifying effect of the antirachitic vitamin D in the food and of ultraviolet radiation. A close connection became evi-

dent in 1924 from the work of Steenbock and Black,[12] who showed that certain foodstuffs after irradiation by a mercury-vapour lamp become antirachitic. The latest development of this series of investigations is the observation of Rosenheim and Webster[13] and Windaus and Hess,[14] who found that ergosterol, a substance widely distributed in nature and present both in the skin of man and of other animals and in many foodstuffs, became activated to vitamin D when exposed to ultraviolet radiation.

Thus, it is now generally accepted that exposure of the skin and of foods to the sun or to other sources of ultraviolet radiation controls bone calcification by the synthesis of the antirachitic vitamin D from ergosterol. The beneficial result on tooth calcification of irradiating the animal[15] or the food has been demonstrated. Ergosterol is a constituent of many foods which, when irradiated, develop a calcifying action and so tend to produce well-formed teeth. Thus, if olive oil, a substance deficient in vitamin D, is irradiated, it assumes potent calcifying properties when taken by mouth. Butter, which has some calcifying action before being irradiated, is much more active in this respect after irradiation. Cereals which, as will be seen in the next section, actively interfere with calcification before irradiation, may actually assist the calcification of teeth after such treatment.

It is evident, therefore, that in a country where there is plenty of sunlight and where the body is exposed to it, perfect teeth may be produced under those dietetic conditions which in a sunless land such as England would result in somewhat imperfect calcification.

SUBSTANCES INTERFERING WITH CALCIFICATION OF TEETH

Of all the foods tested, one group definitely interferes with calcification of teeth: that is to say, the foods of this group are in a specific sense antagonistic to vitamin D. If there is plenty of vitamin D present in the diet, the anticalcifying action of this group of foods is completely neutralized. On the other hand, the greater the amount of anticalcifying foods eaten, the more necessary is it to increase the supply of vitamin D.

Now the chief foods which have this anticalcifying influence on teeth and jaw formation are the cereals and certain cereal products. They differ among themselves as to their intensity of action. The most potent so far discovered is oatmeal and the least potent is white flour. Between these extremes are found other cereals, somewhat in the following order: oatmeal (worst), maize, barley, rye, wholemeal flour, rice and white flour. The germ of a grain, e. g., wheat, maize or rye germ, has a more powerful action in interfering with calcium deposition than the endosperm. (Fig. 6.)

These results are unexpected, and suggest the presence in cereals of a class of substances having a harmful effect on calcification, which have been described by Edward Mellanby as "toxamins[16]" and which can be antagonized in their action by vitamins. Moreover, oatmeal and wheat germ, which have been found to be special offenders as regards tooth calcification, are richest in those elements,

12. Steenbock, H., and Black, A.: J. Biol. Chem., 61:405 (Sept.) 1924.

13. Rosenheim, O., and Webster, T. A.: Lancet, 1:306 (Feb. 5), 1927.

14. Windaus, A. J., and Hess, A. F.: Proc. Soc. Exper. Biol. & Med., 24:461 (Feb.) 1927.

15. Mellanby, May: Brit. Dent. J., 45:545 (May 1) 1924.

16. Mellanby, Edward: Brit. M. J., 2:849 (Nov. 4) 1922; M. Res. Coun. Spec. Rep., Series 93, 1925.

calcium and phosphorus, which go to the formation of teeth. A result of this nature again illustrates how useless it is at the present time to assess the calcifying qualities of a diet by its content of calcium and phosphorus. The amount of these substances required depends on several conditions including the amount of vitamin D and the amount and type of cereal.

The anticalcifying effect of oatmeal is not destroyed by cooking or by heating at 120 C. for several hours. It can be destroyed by boiling the cereal with dilute acid, such as 1 per cent hydrochloric acid, for two hours. Besides being completely antagonized by the presence of vitamin D in the diet or by exposure to a source of ultraviolet radiation, the anticalcifying effect can be re-

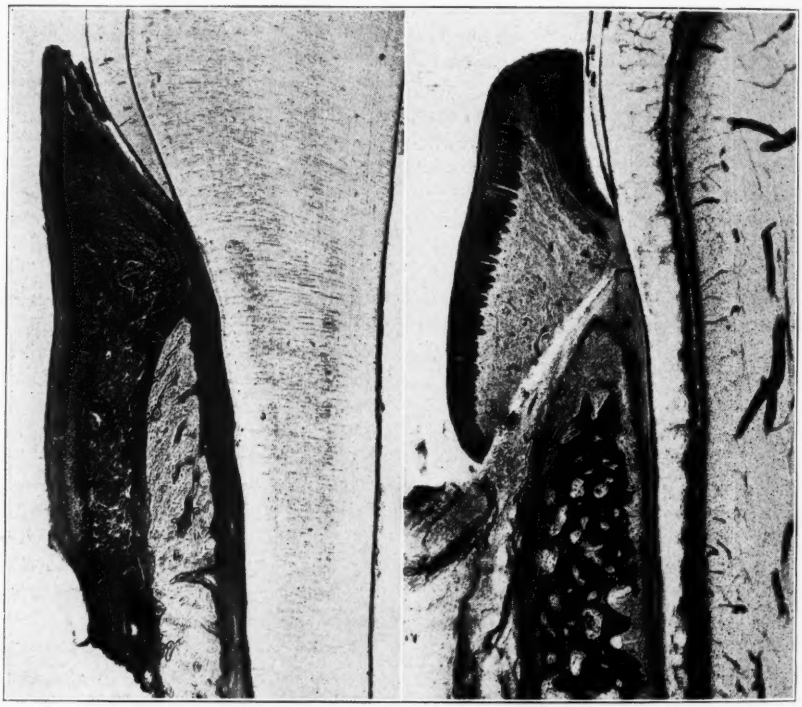


Fig. 8.—Sections of the neck region of two carnassials of puppies, showing the variation in the structures which result from the addition to or omission from the diet of vitamin D. Left: Thick enamel and dentin. The attachment of the gum epithelium to the enamel is shown. The alveolar bone is well calcified. Right: Thin enamel and dentin with many interglobular spaces and wide odontogenetic zone. There is proliferation of the epithelium of the gingival region in the finger-like process, and failure of attachment to the enamel. The subgingival tissue is disorganized and the alveolar bone is badly calcified and irregular, with some osteoid tissue at the crest.

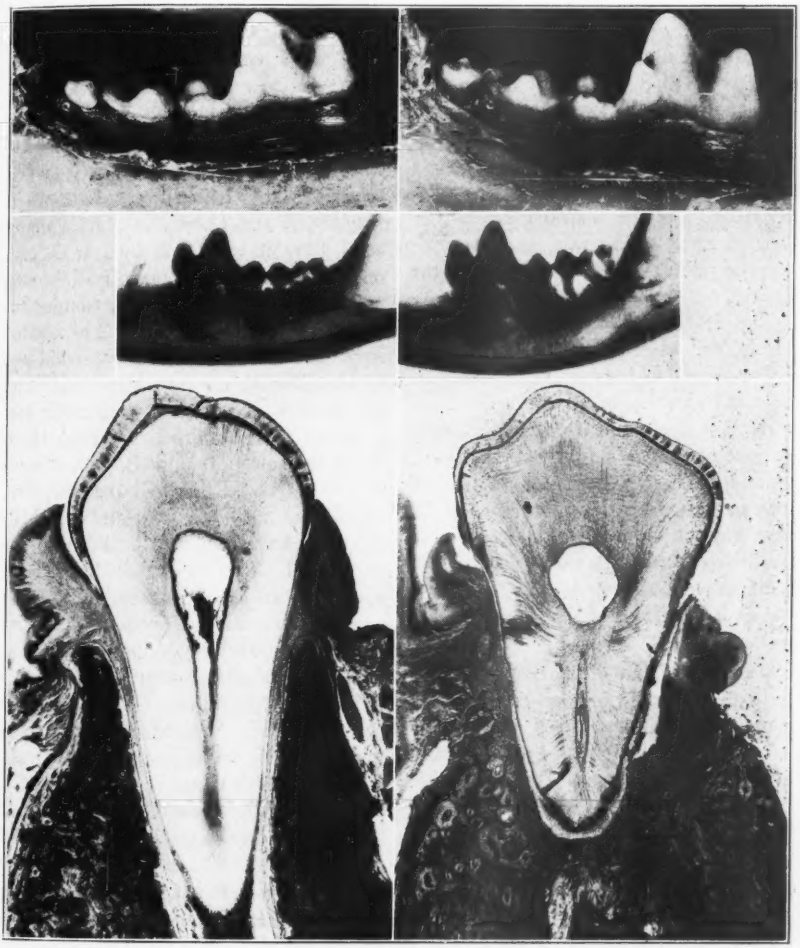


Fig. 9.—Portions of the mandibles with the third lower molars of two puppies, showing the influence on the onset of periodontal disease of the diet during the developmental period. Puppy A (views to the left) was given an abundance of vitamin D in its diet during the developmental period (four and a half months), while puppy B (right) had a diet deficient in vitamin D. Later, both dogs received deficient diets until their death at the age of 3½ years. Puppy A shows nearly normal tissues, while puppy B shows recession of the gum (right, above and below) and absorption of alveolar bone (right, center and below).

duced by adding an extra amount of calcium, especially in the form of calcium carbonate, to the food eaten. Without some vitamin D, increasing the calcium will not in itself allow the production of perfect teeth, but will only

diminish the interfering influence of the cereal factor on teeth calcification.

It may be added that little or nothing is known as to the chemistry of the substance possessing this anticalcifying influence. It does not appear to be directly related to the fat of the oatmeal, for this can be removed and still leave the effect. Again, most of the carbohydrate can be digested away by diastase, and the anticalcifying effect is still obtained with the residue.

The acid-base ratios of the different cereals, and indeed of many other foodstuffs, appear to bear no relationship to their influence on the development of the teeth. For instance, there is little difference between the figures for oatmeal, white flour, barley and rice, although the difference between the effect of some of these substances on developing teeth is great. Milk and eggs both greatly assist calcification, and yet, in the first case, the ash is basic, and in the second, acidic, in character.

Now one of the ultimate purposes of the experimental work on the teeth of animals was to determine, if possible, the main conditions responsible for the susceptibility of certain teeth to caries. Although the success of this part of the work is so far not great, it has produced some interesting results which, in view of possible future developments, will be mentioned.

An initial difficulty in connection with experimental methods in dental research is that of producing caries in the teeth of animals under experimental conditions so that a scientific study of the problem can be made. For many years, I have attempted by dietetic and other means to find a method whereby caries could be produced regularly and at will in dogs, rabbits and rats, but so far with uncertain success, especially in dogs. For instance, the daily addition of glucose over long periods (three years) to an already soft, pappy diet has not resulted in the development of caries.

In experimental rabbits, on the other hand, the exposed dentin on the occlusal surface of the molars, especially when the diet of the animals was deficient in vitamins A and D, was in a great many cases soft; it readily stained with carmin, and decalcified sections showed gram-positive bacteria in the tubules together with liquefaction foci. The administration of *Streptococcus mutans* did not increase the liability to infection. The molars of wild rabbits showed much less tendency to become infected than those of the experimental animals. In conjunction with Dr. Kilian Clarke and Dr. MacLean, dogs whose teeth varied in structure have been fed on different experimental diets to which have been added cultures of streptococcus. It has not been possible to produce caries by this means, nor by giving cultures of *Bacillus acidophilus* over long periods.

In 1922, McCollum, Simmonds, Kinney and Grieves[9] reported an investigation on lesions found in the teeth of rats fed on deficient diets, varying primarily in the amount of fat-soluble vitamin, calcium, phosphorus and protein. They found "caries-like" lesions in more than 5 per cent of rats fed on a low calcium and fat-soluble vitamin diet, and less than 2 per cent in those fed on diets rich in fat-soluble vitamin, whether the calcium was high or low, but none in their stock animals fed on a mixed diet.

Grieves[17] later described these results in more detail. He made sections of some of the teeth showing caries-like lesions and stated that these showed areas of

17. Grieves, C. J.: J.A.M.A., 79:1567 (Nov. 4) 1922.

enamel decalcification and enlargement of the dentinal tubes.

Toverud[18] found some macroscopic lesions resembling caries in the teeth of rats fed on diets low in calcium and fat-soluble vitamins.

Howe[19] has made extensive investigations chiefly on guinea-pigs and monkeys and finds changes resembling caries when the diets are deficient in vitamin C. In a recent report,[20] he states that the most rapid and pronounced caries in monkeys has occurred when the diet has been largely composed of gelatin and cereals; that a deficiency of the antiscorbutic factor has played a part in the production of caries; that excess of sugars and starches has not resulted in caries in nine months; that monkeys fed on milk, vegetables and fruit diet have excellent teeth.

Marshall[21] says that, in experiments on dogs, he did not find any evidence of the development of caries, but he reports[22] the presence of carious lesions in rats fed on diets deficient in fat-soluble vitamins. These lesions only developed in the older animals, never in the young. He was unable to arrest the progress of caries when an animal on a previously vitamin A-deficient diet was later given one containing vitamin A.

If the claims of these investigators can be substantiated, they go a long way to prove the relationship between certain specific dietetic factors and the development of caries.

Table 3.—Relationship of Caries and Diet*

Main Dietetic Differences	Average Number of Teeth per Child in Which Caries Increased in Eight Months	
	First Investigation	Second Investigation
A. Abundant fat-soluble vitamins and calcium; no oatmeal	1.4	1.8
B. Less fat-soluble vitamins and calcium, oatmeal	5.1	5.8
C. Intermediate between 1 and 2	2.9	3.0

*Dr. Pattison found that the calcium content of the saliva in the children of group A was high, while it was low in group B and intermediate in group C.

Since it was shown experimentally that teeth varied in their resistance to external stimuli according to the diet given, and since the structure of secondary dentin in man varied with the resistance of the teeth to caries, the possibility of controlling the resistance of the teeth of children to caries by dieting presented itself. This possibility of altering the resistance

18. Toverud, Guttorm: J. Biol. Chem., 58: 583 (Dec.) 1923; den Norske Tandlaegeforenings Tidende (Supp.), 1926.

19. Howe, P. R.: Experimental Pyorrhea, J.A.D.A. 6:413 (May) 1929; Dent. Cosmos, 63:1086 (Nov. 1921); Diet as Related to Prevention of Mouth Disease, J.A.D.A., 10:755 (Aug.) 1923.

20. Howe, P. R.: Investigations of Dental Caries, J.A.D.A., 14:1864 (Oct.) 1927.

21. Marshall, J. A.: J.A.M.A., 81:1665 (Nov. 17) 1923.

22. Marshall, J. A.: Dental Caries and Pulp Sequelae Resulting from Experimental Diets, J.A.D.A., 14:3 (Jan.) 1927.

of erupted teeth to caries is suggested by an investigation carried out by Dr. Lee Pattison and me, in which we showed that even when a tooth is imperfectly calcified, the onset of caries can be controlled to some extent by specific variations in the diet.[6] All evidence thus far obtained, in fact, emphasizes the importance of controlling resistance to infection by diet and reduces the relative importance of the immediate bacterial cause of caries.

Table 4.—Relationship of Diet and Caries*

Main Differences in Diet	Number of Children in Group	Average Number of Teeth per Child Showing Initiation or Increase of Caries	Average Degree of Increase of Caries per Child	Average Amount of Hardening or Arresting or Caries per Child
A_3. Institutional diet plus vitamin D (radiostol).....	21	1.0	1.1	3.9
A_1 and A_2. Abundant fat-soluble vitamins.	18	1.4	1.7	3.7
B_1 and B_2. Much less fat-soluble vitamins than A_1 and A_2; oatmeal in place of some of bread of A_1 and A_2.....	19	5.0	6.0	0.2
C_1 and C_2. Intermediate quantity of fat-soluble vitamins; no oatmeal.....	20	3.3	4.5	1.2

*Average age of Children, under 6 years

In the work carried out in conjunction with Dr. Pattison, three groups of children were fed on (A) diets which, on the basis of the animal experiments, should insure good calcification (i. e., the diets included a high milk intake, eggs and cod-liver oil); (B) diets with definitely lower calcifying properties, including oatmeal, less milk, and having olive oil substituted for cod-liver oil; and (C) the ordinary hospital diet with calcifying properties intermediate between A and B. The teeth were charted for the amount and character of dental caries at the beginning of the special dietary and again after an averge period of about eight months, and it is shown that those children in group A on a diet which should insure good calcification developed about one-fifth as much caries as in group C, with group B about half way between them.

It seems evident from this investigation that the incidence and spread of caries in the teeth of children can be directly influenced by varying those substances in the diet which have been shown above to influence dental structure in animals, and in addition, to alter the resistance of the teeth to harmful stimuli. Further work of this type on a large scale is now in progress in England, and it ought to be possible in the near future to narrow down the conditions so as to

lead to a more accurate interpretation of the earlier investigations.

Recently, in order to test the effect on the teeth of a single factor, a group of children have been fed on the ordinary hospital diet, but with the addition of a daily dose of vitamin D in the form of from 1 to 8 c.c. of irradiated ergosterol. The spread of caries was greatly reduced, as it was when diet I of the previous investigations was used, but a still more striking result was the amount of arrest of caries.

The evidence gained by the examination of secondary dentin in a large number of teeth and by investigations carried out on children, when taken in conjunction with the artificial production of secondary dentin in animals, demonstrates that diets containing abundant fat-soluble vitamins, such as cod-liver oil, egg yolk and milk, are more likely to bring about resistance to the onset and spread of caries than diets containing little of such vitamins and much oatmeal.

The experimental work on the etiology of periodontal disease has given some more promising results, which suggest that the diet eaten during the period of development is of great significance in the liability of the tissues to infection in later life.

Now the chief structural defects seen when vitamins A and D are deficient in the diet during the period of development (Fig. 8) are as follows:

1. The disorganization of the tissues of the gingival region, with a tendency to proliferation of the subgingival epithelium and the formation of finger-like processes, and sometimes growth rootwards of the epithelium which appears normally to end at the amelocemental junction.

2. Imperfection of the attachment of the epithelium to the rough and hypoplastic enamel, generally resulting in a deeper gingival trough.

3. Abnormal arrangement of the gingival connective tissues.

4. The irregular thickness of the periodontal membrane.

5. Imperfect development of the alveolar bone, and especially of the alveolar crest and also of the lamina dura, with the inclusion of much osteoid tissue and poorly calcified bone.

6. The irregular alinement of some of the teeth, and the "tilting" of the whole tooth in relation to the jaw.

As regards the etiology of these changes, it is interesting to note that whereas defective bone calcification accompanies a deficiency of vitamin D, epithelial hyperplasia has been shown by Mori[23] and others, including Wolback and Howe[24] and Green and Mellanby,[25] to result from deficiency of vitamin A in the diet. Deficiencies in vitamins A and D, the outstanding factors of the diets used in the present work, were no doubt largely responsible for the pathologic changes now described. No data are yet available as to the effects of a deficiency of either vitamin A or vitamin D alone, though experiments which should decide the question are in progress. It is interesting to note that the defects produced by these dietetic deficiencies during the developmental period are similar to those sometimes described as being typical of the early stages of so-called pyorrhea, a subject recently stud-

23. Mori, S.: Bull., Johns Hopkins Hosp., 33:357 (Oct.) 1922.

24. Wolbach, S. B., and Howe, P. R.: J. Exper. Med., 42:753 (Dec.) 1925.

25. Green, H. N., and Mellanby, Edward: Brit. Med. J., 2:691 (Oct. 20) 1928.

ied in man by Box,[26] Gottlieb,[27] James and Counsell,[28] Turner[29] and others.

So far, in my experimental work, two aspects of the subject have been considered: (1) the relationship between the original structure of the periodontal tissues and their liability to become infected under varying conditions, and (2) the relationship between diet and the liability to infection when the structure of the tissues is constant, whether it be normal or abnormal.

Observations on about twenty-four dogs, extending over some years (in some cases five or six years), indicate that:

1. Periodontal disease is most liable to occur in an adult dog whose diet, although otherwise adequate, was deficient in vitamins A and D during the first six or eight months of life; that is, during the period of active development of the periodontal tissues. If during these early months, the diet is deficient in vitamins A and D, periodontal disease develops in spite of the subsequent addition of these substances to the food. If the diet is rich in these vitamins in the early months of life, the tissues are much more resistant to the disease even when a deficient diet is later given for a lengthy period.

2. The diet during later life has also some influence on the onset and progress of periodontal disease, especially when the tissues are imperfectly developed.

An example of the experiments is given below.

When 8 weeks old, two dogs of the same litter were given the same basal diet to which an abundant of vitamins A and D was added in the case of one dog only. After four and one-half months, and for the following eight months, the diets were reversed, but during the next two and one-half years both dogs received a diet deficient in fat-soluble vitamins. They were killed when about 3½ years old. The gingival tissues of the dog which had a diet rich in vitamins during the early developmental period remained almost normal. Little absorption was seen in the roentgenograms and microscopic sections. (Fig. 9.) The gingival tissues of the dog whose early diet had been deficient in vitamins showed recession of the gum and pockets in several regions. Loss of alveolar bone was seen in the roentgenograms, while sections portrayed proliferation of epithelium and extension rootward and infiltration of inflammatory tissues.

COMMENT

The investigations described above indicate that:

1. The high incidence of dental caries in children in this country is associated in a general way with defective structure.

2. It is possible to produce in puppies and other animals perfect and imperfect teeth by slight, but specific, alterations in the diet, and, as far as the present limited experience goes, the same facts apply to children.

3. The resistance of teeth to caries and attrition can be influenced by diet independently of their original structure.

4. The structures of the periodontal membrane are controlled, as are those of the teeth, by specific alterations in the diet, and these structures play the chief part in the onset and progress of peri-

26. Box, H. K.: Studies in Periodontal Pathology (bulletin), 1924.

27. Gottlieb, Bernard: Deutsch.-Monatschr. f. Zahnheilk., 39:142, 1921; Schmutzpyorrhoe, Paradentalpyorrhoe und Alveolaratrophie, Vienna, 1925.

28. James, W. W., and Counsell, Arthur: Brit. Dent. J., 48:1237 (Oct. 15) 1927.

29. Turner, J. G.: Brit. Med. J., 1:998 (June 4) 1927.

odontal diseases. The diets throughout life also greatly influence the onset and progress of these diseases.

These results suggest that the problem of dental caries and periodontal disease is fundamenatlly a problem of nutrition, and they also supply an indication as to how these scourges can be met with a probability of success.

Since there are two quite different meanings in dental literature attached to the term "dietetic hypothesis," it may be well to state that, in the investigations here reported, the term is used in reference to the food in relation to metabolic processes in which the diet influences the teeth specifically, not so much by a direct action in the mouth, as by influences brought to bear on the developing or developed teeth after the food has been digested and absorbed, and by its products carried in the blood stream to the dental and other tissues. Many writers appear to use the term simply in reference to the influence of food actually in the mouth on the development of caries, the presence of fermentable sugars, the softness of the food, etc.

The first practical problem is to procure the formation of perfectly calcified teeth and jaws in the growing child. Knowledge regarding the food factors controlling the calcification of teeth and jaws should render this possible. The two main factors influencing dental structure and, to some extent, arrangement of teeth in the jaws, have been shown to be vitamin D, which aids calcification of teeth and the calcification and growth of jaws, and cereals, which interfere with these functions. The effect of ultraviolet radiation, also conducive to good dentition, is now known to be due to the production, by the rays, of vitamin D in the tissues. A minimum amount of calcium and phosphorus is, of course, essential, but this minimum varies with the amount of vitamin D in the diet, and cannot be stated as an absolute quantity.

The degree and character of dental calcification are, then, the result of a battle between these factors, and the defective calcification so commonly present in human teeth can be assigned largely to a relatively deficient intake of vitamin D in the food, with lack of sunshine on the body and with a relatively high proportion of cereal. Caries is associated with defective structure, and since it has been shown that diet affects the resistance of teeth, apart from the original structure, the full effect of diet as regards resistance to caries can be obtained only by giving children diets which have been shown to produce perfectly formed teeth during the actual calcification processes, and by continuing the diet along similar lines after the teeth are calcified.

The calcification of the deciduous teeth starts while the infant is *in utero*, and therefore the special dieting should be applied to the mother during pregnancy and lactation, partly to insure an adequate supply of those substances essential for the child, and partly to prevent the mother herself from going short of these essential factors when giving her own supplies to the developing embryo.

The question may be asked: Are these deductions from experimental work in line with common experience? For instance, do the facts explain why the teeth of English people are as bad as they are, while the teeth of natives living in tropical lands, or those of the Eskimos in their natural habitat, are comparatively good? I think it can be stated that, on the whole, this is the case. Although the diet of natives in tropical countries is sometimes unbalanced, because it contains much cereal and few fat-soluble vitamins, the infants are often breast fed for long

periods, and the sunshine striking their naked skin supplies vitamin D, which tends to antagonize the effect of the cereal and to make up for the deficiency of vitamin D in the food. It must be remembered that the distribution of ergosterol is widespread in nature, and if there is abundant sunshine, with exposure of the skin, and perhaps of food material, there is no reason to fear a deficiency of the provitamin. The diet of the Eskimos, on the other hand, is deficient in cereals, and is largely made up of fish and animal foods containing much fat and its associated vitamins. Thus, in both cases, the amount of vitamin D in the body may be comparatively high and this fact no doubt accounts for better formed teeth. It has been stated that when these native people leave their natural habitat and come to live under the dietetic and environmental conditions of civilized man, their teeth are as susceptible to caries as ours.

As regards the distribution of caries, two points may be mentioned which are generally accepted as true, although they are not statistically established. The first is that, on the whole, the teeth of the wealthier classes are less affected than those of the poor. My observations[30] are in accord with this suggestion. This might be expected from the experimental results, since the natural foods producing good teeth and the least tendency to caries are expensive, and include milk, butter and eggs, whereas, the cheaper foods, on which the poorer people depend, include more cereals, which have been shown to hinder calcification.

The second point is the greater freedom from caries of the children brought up in institutions than of the same class of children living in their own homes. This state of affairs has been noticed by many observers, among whom may be mentioned Ainsworth,[31] who quite recently recorded this fact. It seems to me that this difference in the distribution of caries would also be expected on the nutritional or dietetic hypothesis suggested by the results of animal experimentation. Most institutional diet includes, among other vitamin D-containing foods, a regular supply of milk, which is so often lacking in the average poor household. I think it may be claimed that, on the whole, the results obtained by the experimental work and supported by clinical investigation are in accord with experience as regards the distribution of dental caries in human beings.

30. Mellanby, May: Brit. Dent. J., 44:1 (Jan. 1), 1923.

31. Ainsworth, N. J.: M. Res. Coun. Spec. Rep. Series 97, 1925.

ELIMINATION OF PAIN IN DENTISTRY*

By ELMER S. BEST, D.D.S., Minneapolis, Minn.

EACH year, there are graduated from dental colleges into the ranks of the practitioners of dentistry a large number of young men. They come with various qualifications to practice their profession; some are simply good mechanics; some are simply good surgeons; some are both.

Formerly, it was considered essential that a young man be chiefly a good mechanic in order to qualify as a dentist. It is found from experience that the dentist can hire mechanics to do the mechanical part of dentistry. This releases the dentist for the time otherwise spent in the laboratory, and he can concentrate on the surgical preparatory phase of it and on the placing of the restorative structures. He cannot hire anyone to do this work for him.

On the young men coming into the profession, we must largely depend for any extensive change in the point of view of dentists as an organized group. To attempt any radical change in the procedure of a large number of dentists who have been in practice for a number of years is well nigh futile.

If any plan or idea has merit, it will, of course, attract a certain number of dentists who are always on the alert for something new, interesting, progressive and of value. It is true that the great bodies move slowly, and it is right that such be the case, as we pass through eras of extreme emotionalism at times and it is the conservative point of view of the mass that many times saves the day.

To all classes, the recent graduate chiefly, and then to the keen, alert enthusiast, and the more conservative, an appeal is made at this time to give more serious thought to, and the constructive application of, the greatest advance that can be made in the practice of dentistry: the elimination of pain.

Pain is mental and physical. Patients have, on occasions without number, remarked that the fear of having their teeth worked on caused them more pain than the actual work. We, therefore, have the mental as well as the physical to deal with.

We frequently find that, on their first visit to the dentist, young patients come in so frightened and nervous as to make it impossible to do anything for them. What is back of this? Someone has been talking about something in connection with dentistry that put fear in the minds of these children. What was it? What in the minds of the laity is still the outstanding thing in connection with the practice of dentistry? Nothing more or less than pain. They think, talk, feel and act "pain" in connection with dentistry. For certain reasons, any and all of which are without sense, they convey this idea to children. To what extent

*Read before the Section on Operative Dentistry, Materia Medica and Therapeutics at the Seventy-First Annual Session of the American Dental Association, Washington, D. C., Oct. 10, 1929.

is the dentist responsible for this situation?

The new little patient, on the occasion of his first visit to the dentist, is invariably accompanied by mother, father or nurse, who proceeds to demonstrate to the dentist that they thoroughly understand or misunderstand, this depending on the point of view, the education of children, by saying, "Now, sit right up in the chair; the doctor isn't going to hurt you." Immediately, the idea of fear of pain is again literally forced on the mind of the child by a kind but thoughtless parent or nurse.

So much damage is done in this way by parents that many dentists prefer that they withdraw from the operative rooms as quickly as possible. One friend of mine has a sign in his waiting room, "Parents not allowed in the operating room with children."

Therefore, one of the first things to be accomplished in the control of pain is to practice a type of dentistry for children which requires the absolute minimum of pain and discomfort. How is this brought about? Here is the answer: Begin early. Have the child patient in every two months for prophylaxis and any small fillings that may be necessary in the deciduous teeth. To prevent involvement of the pulp, with the accompanying inevitable pain, be sure that the mother or nurse understands brushing and the use of the floss silk in keeping the proximal surfaces clean and free from decomposed food. In order to make sure that this is being done and that cavities are not developing on these surfaces, interproximal roentgenography as advocated by Howard R. Raper should be carried out. To further assist in preventing pulp irritation and possible loss due to caries developing, the parent or nurse should be continually reminded of the proper diet for young children, and the danger of overindulgence in sweets should be kept constantly before them. If a young child is started out along these lines, he positively swears by his dentist, and any thought of fear of him and his work is entirely removed from the child's mind. Pain no longer enters the picture.

In adults, very much the same conditions prevail. A large percentage of patients remain away from the dentist because they dread the pain incident to having work done. This fear is eliminated in large measure by having the patients on a regular three-month prophylactic call list. In this way, cavities just beginning are discovered. One of the greatest aids in this service is a full-mouth roentgen-ray examination each year.

In a very short time, it will be found that instead of staying away from the dentist when they feel something has gone wrong with the teeth, they go at once to see what has happened. They do not then think of their visits to the dentist in terms of pain.

This interesting relation between patient and dentist removes in large measure that mental pain which countless thousands feel when they contemplate a visit to the dentist. This I know from observation and experience.

If anyone does not believe that patients think pain in connection with dentistry, listen to the conversation in busses, street cars and other places where people congregate. If you keep your ears open, you will hear people boast of having been to the dentist. Why boast? Simply because they think they are smart to have survived it. Do they tell of their experience in terms of delight? Not much. "He nearly took my head off," is probably what 50 per cent of them say. The den-

tist can correct this situation, and it is his plain duty to do so.

And now we come to actual physical pain in connection with the teeth and their supporting structures and in connection with surgical work.

I have long felt that a dentist has no more right to ask a patient to submit to the pain and annoyance of an operation on sensitive tissues without proper precautions being taken to relieve it than the general surgeon has to do his work and allow the patient to suffer and make no attempt to relieve him.

This, then, means that, in cavity preparation and in the preparation for full and partial veneer crowns, the work should be done under a local anesthetic. The various injections have now been so simplified that anyone can easily master them. With the method now largely in use, by which reliable manufacturers prepare anesthetics in glass containers for use in hypodermic syringes, the handling of local anesthesia is greatly simplified.

While the control of pain is nicely secured in this type of work, great caution must be exercised that the tooth in cavity preparation be not overheated, with resulting injury to the pulp, and pain later on. In making even the injection itself practically painless, a pellet of cotton dipped in cresatin is placed on the mucous membrane at the point of injection for a few seconds. If local anesthetics were used in setting inlays, crowns and bridges, in addition to preparing cavities, the benefit would be felt by the dentist as well as by the patient.

We have eliminated toothache caused by proximal and occlusal cavities by preventing the development of such cavities.

We have prevented the pain of cavity preparation.

We have also ceased to cause that excruciating pain caused by placing cement in a sensitive cavity, or on a crown abutment incident to making a restoration. As a further aid in controlling pain, it will be found that to wipe out a cavity which has been dried with phenol and then with warmed alcohol is very effective.

It is a common experience that after cavities have been prepared and sealed with a temporary filling, the latter loosens and becomes dislodged, an open cavity remaining, which, being extremely sensitive, not only causes the patient constant pain until the filling is replaced, but may be the cause of a serious irritation (bacterial as well as thermal) to the pulp. In experimenting with temporary fillings, it has been found that not only can it be made practically impossible to dislodge, but also the sensitiveness found in these cavities when the cement is placed in them incident to setting inlays can be reduced quite materially.

To this point, we have made some progress, but only partial progress. We have patients who, in spite of the fact that they feel that everything possible is being done for their comfort, when they come into the waiting room, experience a wave of fear, and they find themselves in a state of great nervous tension, which makes them very difficult to work for. In these cases, if a mild sedative is given fifteen minutes before operating, it will be found that they are quite relaxed.

And now we have another group to consider, and they are very numerous, i. e., the patients who, in spite of the fact that they realize that everything we can do to prevent pain is being done, become almost rigid and frequently hold their breath the minute a bur revolving in the engine touches a tooth. On this group, I have spent more time and thought than on all the others combined.

A friend of mine relates the following experience which refers to this particular group. A patient of this type, having run up quite a large bill for broken appointments, finally screwed his courage up to the highest pitch and came to the office. After many excuses for not sitting in the operating chair, he finally seated himself. He saw the dentist turn to his cabinet, evidently to take out an instrument (which happened to be a mouth mirror). Without waiting to see what it was, he closed his eyes and started to groan. The dentist said, "Why, man alive, I haven't even touched you." The patient ceased groaning, turned and said, "No, doctor, you didn't touch me, but you came awfully close to it."

On questioning many of these patients, it was learned that the thing that bothered them was the fact that when they opened the mouth and the dentist began cutting, they felt that they might be terribly hurt and they had no way of stopping it. They were willingly or unwillingly at his mercy. In fact, if they tried to speak to the dentist, the tongue would get caught and they would be seriously injured. They uniformly agreed that if they had some means at their disposal whereby they could only stop the engine if they wanted to, it would help them greatly.

I, therefore, had constructed a stop switch connected with the engine, and fastened it onto the left arm of the chair. The patient holds this little pendant switch in his hand, and if he feels that he is going to be hurt, or is actually being hurt, he presses the switch and shuts off the motor. What a godsend to them! As they have repeatedly said, "You give us an even break on it now."

At first thought, one is inclined to feel that such an arrangement would interfere greatly with the progress of the work, because the patient would be constantly stopping the engine. As a matter of fact, the reverse is true. After they see that it really works, they seldom use it, and remain quite contented. Some patients just touch the button with a slight pressure of the thumb, and this minute cessation of electric current being felt in the handpiece, the bur is moved to another location.

Another cause of great distress to patients is acute traumatic occlusion. This may be due to a recent shifting of the cuspal relation which results from loss of a tooth; or it may occur in the case of an inlay, especially if made of one of the very hard golds, which has been set with considerable pressure. The patients complain of a severe pain in a certain region, but often they are unable to locate it in any one tooth. When you ask them to close slowly, they move the mandible a little to one side, or back or forward, and do not register in a position that might hurt them as they have trained themselves to avoid this exact relation.

With a carbon paper between the teeth and instructions to "chop," the patient will close several times in normal relation. It may be necessary to assist him by taking hold of the chin and raising and lowering it several times, each time bringing the teeth together in centric occlusion. With the carbon paper, the spots will be seen on the occlusal surfaces. These cuspal levels are then so reshaped that the occlusal stress is relieved. In most cases of combined pericementitis and pulpal hyperemia, as a general rule, complete relief will follow.

Again, we have the case of the tooth with the extensive caries, almost, and in some cases actually, exposing the pulp. Owing to our desire to relieve the patient of pain and discomfort and yet maintain pulp vitality, the following operation was

worked out: After removing all of the carious dentin from the side walls of the cavity, the pulpal and axial walls are attacked. With good vision and access, this dentin is cautiously removed and the cavity is well cleaned out, but the pulp is not exposed, even though a layer of involved dentin is all that prevents its exposure. It is thoroughly irrigated with warmed surgical solution of chlorinated soda (Dakin's). This mopping or sponging process should be kept up for ten or fifteen minutes. The cavity is then dried and a preparation of zinc, magnesia, silver nitrate powder and eugenol is mixed to a fairly thick consistency and a drop placed in the base of the cavity with a fine probe. With a small dry pellet of cotton, this mixture is gently spread over the cavity floor. Excavators are now used to trim the material away from the margins. Particular attention must be paid to its removal from the gingival margin.

While the material contains silver nitrate, if due precaution is taken to keep it away from the margins, no discoloration will be apparent. The next step is to cover the mixture with oxychlorid of zinc cement. Oxychlorid is used for the reason that it is one of the few cements through which moisture will not pass. After it is in place, the cavity is filled with oxyphosphate cement, and the occlusion is tested with carbon paper and relieved. The tooth is then given a period of rest. If no symptoms contraindicate, the permanent restoration is placed in a few weeks.

This operation does not lend itself to a careless or indifferent technic, but must be carried out with the closest attention to detail. The results observed in the series of cases referred to were astounding. Pulps for which but little hope could be held out were found to retain their vitality and an absence of unfavorable symptoms, together with encouraging roentgenographic evidence, seemed to indicate success. Further observations justified a feeling of optimism, and after considerable time, the operation was adopted as practical. It is here offered as a contribution to modern preventive dentistry.

In simple scaling of the teeth, there is little pain caused, hence, but little consideration need be given other than extreme care not to unduly injure the tissues. In the more advanced cases of periodontoclasia, where there are deep pockets with infected tissue to be removed, it will be found an invaluable aid if a local anesthetic is judiciously used in order that these areas may be thoroughly curetted. When such a condition prevails throughout the mouth and it calls for treatment, it is a good plan to divide the mouth into quarters and operate one-quarter at a sitting. In order to prevent the pain that usually follows such operations, owing to exposure of cementum, "wondrpak" is used. This will help many a case over an otherwise trying period.

Occasionally, we find a mouth in which the teeth are so sensitive at the necks that the patient simply cannot brush them. In such a case, the use of a local anesthetic is necessary for thorough scaling. This is followed by the use of silver nitrate on the sensitive spots. The patient is then thoroughly coached in interproximal brushing as advocated by Charters. This method is so efficient that I have found it a big help in itself in correcting sensitive areas.

It has not been my intention to cover completely the field of dental aches and pains, but to select a few of the more common, and in a short presentation, rekindle in your minds a desire to eliminate pain in your operations.

If you question the value of this course to the dentist himself, ask anyone who pursues it in his practice whether it is worth while.

DISCUSSION

P. G. Puterbaugh, Chicago, Ill.: It is gratifying to know that enough men are seriously interested in painless methods of performing dental procedures that we have reserved an hour for their consideration. Dr. Best's contribution is a most timely addition to the literature on the subject. The ingenious device that he has described in the form of an electrical switch which enables his patients to arrest the motion of a bur at will is entirely new to me and I am forcibly impressed with its possibilities for good. I am certain that a great many excellent operators do not realize the amount of pain that is produced during the preparation of sensitive cavities for the reception of fillings. Pain is one subjective sensation that is detrimental to the health of any person. It causes digestive derangements, perversion of secretions, endocrine imbalance and general exhaustion far in excess of that caused by fatigue, fright or other emotions; in fact, the exhaustion that results from an hour in the dental chair frequently is so great that it takes several days for the patient to resume his normal equilibrium. It is hoped that the rational employment of the present array of pain relieving devices and methods will soon deliver dentistry from the handicap of fear with which it has for so long been saddled. Without burdening ourselves with a histologic discussion as to how or why dentin is sensitive in varying degrees, let us frankly acknowledge the biologic fact that dentin is usually an extremely sensitive tissue. The ability of human nervous systems to endure nervous irritation is most variable. Impulses that would be regarded as only mildly unpleasant by one person are often interpreted as severe pain by another and, in the latter case, will produce the characteristic reactions throughout the entire body. For that reason, the varying degrees of pain can be measured only by the reactions which their perception causes in each individual. It certainly cannot be accurately estimated by the extent of tissue injury or the anatomic parts invaded. Pain perception is capable of being either minimized or magnified to a considerable degree by voluntary mental effort. That is why suggestive therapeutics is so universally used to assist patients in shutting out pain perception. The results of hypnotic suggestions are variable, being eminently satisfactory with some patients and failing utterly with others. Dr. Best's practice of excluding all persons from the operating room except the patient and operator is most commendable for the very reason that the presence of a third person always interferes with the operator's suggestions to the patient. Regular prophylactic treatments given at intervals not too widely separated offer the best means at our command for dispelling fear and promoting confidence. What is more important, they also enable us to discover and repair carious defects when they are superficial. In fact, if such a routine is carried out, pulp exposure should never occur, and the root canal problem is solved. I find it impossible to endorse Dr. Best's recommendation that the rank and file of dentists generally should assume the additional duty of discussing dietetics with their patients, for the reason that few dentists know more about that subject than do their patients. Dietitians are pretty generally agreed that a thorough study of each person's digestive apparatus and an evaluation of its capabilities is necessary before prescribing a diet, for there is no doubt that "shotgun" dietetic advice is very likely to do harm. In this connection, it is quite interesting to observe that although a great deal of diet propaganda has been aired during the last ten or fifteen years, the rank and file have failed to discover any perceptible change in the condition of the mouths or teeth of their patients. In addition to the minimizing of pain through careful and adroit instrumentation, there are two classes of medicinal agents that are indispensable to the dental practitioner of today. One class obtunds pain perception by its action on the cerebral centers. A typical example of this group is a combination of morphin, one-sixth grain, and hyoscin, one one-hundredth grain. This can be administered by mouth one-half hour before operating and is especially valuable in relaxing the high tensioned, nervous type of patient that suffers much mental anguish from nervous apprehension and dread. A combination of amidopyrin, 3 grains, and acetanilid compound, 3 grains, taken one hour before operating, is less potent but quite satisfactory for many. Another class is that

of local anesthetics which act by blocking the passage of pain impulses emanating from a certain area. The higher centers in this instance do not receive the pain impulses at all. Local anesthetics are indicated when actual pain is experienced. Pulp sensation in the upper teeth is obtunded by the injection of 15 drops of 2 per cent procain solution into the periosteum over the labial surface of the apices of the roots of the teeth to be treated. In the lower teeth, a pterygomandibular injection of 30 drops of solution will anesthetize the side injected. For patients who are possessed of the ordinary degree of mental poise, local anesthesia alone is recommended for all painful procedures. To patients who lack the ordinary ability to control their emotions and to whom the mere vibration of a bur is interpreted as a painful or distressing sensation, amidopyrin or the morphin-hyoscin combination should be administered. For the latter type of patients, the additional administration of local anesthesia should also be employed if sensitive tissues are to be invaded. In closing, I would lend emphasis to Dr. Best's plea for the tactful handling of all patients, for careful instrumentation and for the employment of both cerebral depressants and local anesthetics when indications arise for the obtunding of pain.

Edwin A. Holbrook, D.D.S., Brooklyn, N. Y.: Painless dentistry! What a phrase to conjure with! And yet how many are the crimes that have been committed in its name; crimes against the credulity and confidence of the people entrusting themselves to our care. Fortunately there is less of this form of deception now than earlier in the history of our profession, owing to the control and partial elimination of the charlatan and to an accumulation of knowledge concerning the prevention of pain in dental operations. We must all plead guilty on many counts of causing pain in our operative procedures, but we should never knowingly mislead a patient, young or old, by telling him there will be no pain, when, from the very nature of the case, pain will be inevitable. Quite the opposite method should be pursued. Tell the patients frankly, if they are old enough to be reasoned with, that there may be a little pain, but that every measure will be used to control it. Thus prepared, when the operation is completed, the patient will almost invariably exclaim that it did not hurt so much as he or she thought it would. Dr. Best has very properly treated his subject under two headings, namely, mental pain and physical pain. I shall follow his lead; but at the risk of being accused of espousing the cause of one of the various metaphysical cults of the day, I am going to lay particular stress on mental pain and its alleviation, and will speak from the standpoint of a general practitioner who does no surgery. One of the greatest humanitarian acts within a dentist's power is, by sympathy and tact, finally to overcome the nervousness and terror of the timid little patient making his first visit to the office. The first sitting should be devoted to making a casual examination and to getting acquainted with the patient and permitting him to become accustomed to the new and unusual, and often terrifying surroundings. At the second sitting, we should do just enough excavating to insert a temporary filling over a phenol compound (Buckley) treatment, carefully avoiding the slightest pain. By the third sitting, the child is usually ready to let the operator proceed with his routine. The greatest care must now be exercised not to betray the confidence which has been built so carefully. Never suggest pain, but explain what you propose to do and seek the cooperation of the child by telling him to raise his finger when, for any reason, he wishes you to stop drilling, and always stop immediately on his request. Dr. Best's stop switch is an excellent device, and the theory back of it must fit perfectly into the experience of us all. Focusing the patient's attention on something out of the window, if you are fortunate in having an office above the housetops, will help remarkably in eliminating pain. This idea was given me by a lad, aged 12, who had been a particularly difficult patient. One day he had been especially uneasy during cavity preparation, when suddenly he relaxed, and although the work continued in the same sensitive cavity, he seemed not to mind it. On being asked if the tooth had ceased to be sensitive, he responded that he did not know because he had been counting the windows in the row of houses down the block. This patient has never given any trouble since. He has convinced himself that the pain of dental operations is more than half mental. The attention of young patients can be diverted from the operation in many ways—an unusual toy, a picture book, a running fire of conversation or

stories. A short piece of dental floss or cotton tied to the cable of the engine will fascinate the child for quite a while, as it winds its way back and forth over the pulleys and keep the patient's mind from dweling on what the bur is doing. It is my observation that fear plays a big part in the discomfort of a patient in a dental chair, and this applies to all ages. The actual pain is intensified by the fear of a greater pain momentarily to follow. If you have analyzed the character of pain caused in cavity preparation, you will know that it is the same whether the cavity is shallow or deep. It always feels as though the bur were moving over a thin layer and is liable to crash through at any moment. A greatly intensified pain seems imminent. If you will explain this phenomenon to the patient before proceeding, giving assurance that the sensitiveness will not increase suddenly and that you are not drilling near the pulp, you will find your patients much more relaxed and far less apprehensive. And usually they will admit, when the operation is completed that they really suffered little pain. Continued deep breathing by the patient during the drilling of a sensitive cavity will reduce pain by keeping the mind occupied and by producing a slight general analgesia. It has been my experience that burs with flat sides, such as inverted cones, fissure burs and wheel burs, produce more pain than the round bur. Presumably, there is greater friction where there is greater surface contact and consequently more heat. Sharp instruments firmly grasped and used with positive strokes will help greatly to minimize pain and nerve strain and lessen the time required. I have found only occasional use for local anesthesia, either conductive or infiltration in cavity preparation. It would seem that the dangers connected with its use far outweigh the advantages. Exposure of the pulp and injury resulting in its death is more liable to occur under anesthesia; not to mention the accidents attending the administration of the anesthetic itself. Such a statement may seem unprogressive, but I maintain that, in the light of our present knowledge of focal infection, any method of painless cavity preparation that endangers the life of the dental pulp should be discouraged. But in our quest for painless methods in dentistry, let us never relax our efforts in the direction of thoroughness in cavity preparation. That last small spot or thin layer of decay left in to avoid a moment of pain may be the cause of sleepless nights and the possible loss of the tooth. In a little less altruistic vein, let me suggest that patients will soon forget a little pain, but they will not forget or forgive the failure of a filling. In closing, I wish to affirm the statement made by Dr. Best at the beginning of his paper that the greatest factor in the relief of pain in dental operations will be the reduction in number and extent of cavities through an increased knowledge and practice of preventive dentistry.

GRAPHIC REPRODUCTION OF MANDIBULAR MOVEMENTS IN FULL DENTURE CONSTRUCTION*

By GEORGE P. PHILLIPS, A.B., D.M.D., Boston, Mass.

ALTHOUGH there are many conflicting opinions among full denture specialists as to whether the movements of the mandible are of sufficient importance to necessitate their accurate reproduction or not, there is one thing on which we all agree, and that is, that considerable variation exists between the mandibular movements in most individuals. These variations are attributed to the patient's age and type, and to the way he has been accustomed, or rather has had, to masticate his food previous to the partial or total loss of his teeth.

In other words, these variations are the result of progressive or retrogressive physiologic changes due to age, ill function, unilateral function or total loss of function. It has also been demonstrated by many investigators, such as Gysi, Hanau, House and Hall, that considerable variation exists between the right and left movements of the mandible of the same individual. The significance or importance of these variations will not be discussed at this time. For myself, I consider them of the utmost importance.

Without exception, full denture prosthetists throughout the country are using articulators, either of the semi-adaptable or the fully adaptable type, and they also employ various technics to obtain centric occlusion, and also to adjust their articulators. The fact that satisfactory practical results can be obtained with these various methods cannot be disputed. Experience, study, and investigation has fitted the full denture prosthetist, irrespectively of the methods or instruments he is using, to obtain good results, as long as his methods are based on sound fundamental principles. But the general practitioner, because of his large and diversified practice, has neither the time nor the means, nor has he acquired the necessary training, to employ the methods of the specialist; although he handles the greatest number of full dentures constructed throughout the country.

The service which the full denture specialist can render is obviously limited to comparatively few patients, on account of the expense involved, the limited number of men specializing in this field and their segregation in large cities and communities.

The general practitioner depends almost wholly on the dental laboratory for his mechanical work. Unless we are able to convey to him the importance of the mandibular movement in denture construction, and educate him to convey these ideas to the laboratory man or technician, giving him logical, practical and simple fundamental instruction, our efforts to promote dental education in prosthetics will fall far short of our objective. The purpose of all this investigation and re-

*Read before the Section on Full Denture Prosthesis at the Seventy-First Annual Session of the American Dental Association, Washington, D. C., Oct. 9, 1929.

search work should be to provide means for better dental service to the public, and at a cost within the reach of all. This will never be accomplished, unless we exert a concerted effort to agree on fundamentals, and then proceed to apply them in the simplest manner possible.

I have yet to find a laboratory man who really understands what we mean by anatomic articulation, if I may be allowed to use the expression. I do not refer to the few gifted technicians who have come in close personal contact with some of our outstanding investigators. I mean the average laboratory men. They have all heard of balanced occlusion, condylar inclinations, incisal path guidances, retrusive bites, proper interdigitation, etc., but they have not been taught to visualize or appreciate what bearing these have on the success of the dentures. In other words, they do not know what is expected of a full denture in terms of function. If they are to be entrusted with the construction of our mechanical appliances, it is only logical that they should be acquainted with at least some of our mechanical problems and their solution.

My paper, therefore, will deal with that phase of the question which has to do with educating the general practitioner; by convincing him that (1) mandibular movements are not a state of mind, due to a denture complex, but that they are a fact, and play a very important rôle in the construction of serviceable dentures, and (2) that there are easy and simple methods by which these can be reproduced, and also made understandable to the laboratory man on whom he so much depends.

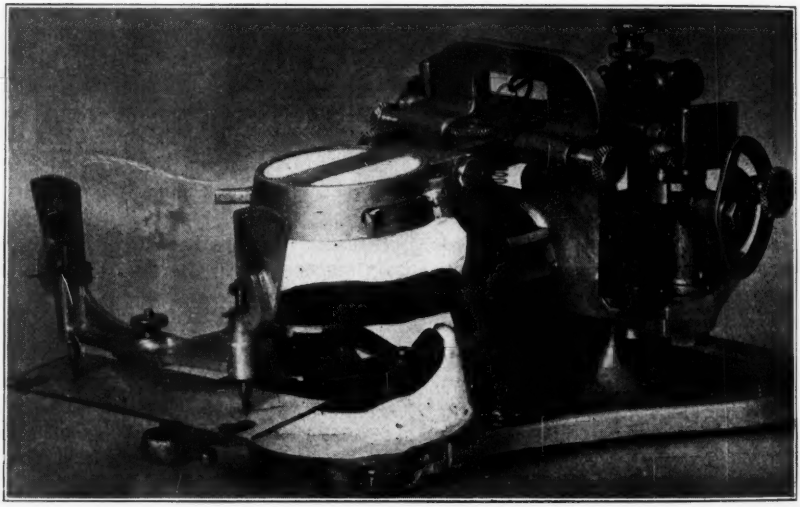


Fig. 1.—Graphic recorder and articulator as presented before the National Society of Denture Prosthetists in Philadelphia in 1926.

I have nothing new to offer, either in theory or interpretation; nor can I improve on or suggest anything that has not

been thoroughly investigated and covered by Dr. Gysi and others. I will simply try to dispel some of the prevailing pessimism regarding this matter, which I am surprised to find in recent writings by some of our prosthetic men, who, I think, ought to know better than to make hasty statements and to come to unsound and illogical conclusions, only to have to retract them later. This shifting back and forth from one method to another has more to do with the helpless attitude of the general practitioner toward denture construction than have the actual difficulties encountered in their construction.

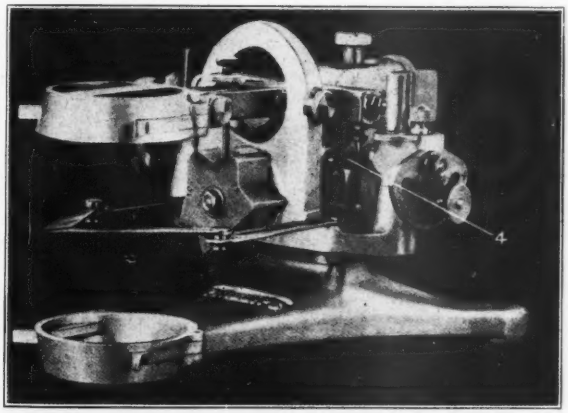


Fig. 2.—The Phillips articulator with mounting plane adjusted.

In my attempt to prove to the general practitioner the existence of mandibular movements executed along planes of varying inclinations, and their importance, which, after once demonstrated, become so simple that they cannot be conscientiously ignored or put aside as unimportant, I have employed a method similar to the teaching methods of experimental physiology.

The experiments which we, in our student days, had to do with the kymograph in experimental physiology must still be fresh in the minds of many present. The kymograph has helped us to get a clearer mental picture of the muscle contractions of the heart and the various muscles with which we had to experiment, than if these had been simply explained to us rather than demonstrated. It is easier to explain something which has once been seen and can always be visualized, rather than to attempt to explain something which has to be imagined or taken for granted. I am using the illustration of the kymograph simply to show that, by utilizing means which graphically record movements and supply us with visible tracings, we get a mental picture of actual happenings so vivid and so thoroughly convincing, as to make it impossible for us to deliberately ignore them.

The idea of graphic records of the movements of the mandible was first presented by me to the National Society of

Denture Prosthetists in Philadelphia in 1926. Since then, the use of the central bearing between two trial plates to record mandibular movements, which is an integral part of the graphic recorder, has been adopted by many throughout the country, and has proved its value. Drs. Hall, Stansbery, Sears and others will bear me out in this. At that time, the idea of graphic reproductions of the mandibular movements was still in an experimental stage, and was mechanically too complicated.

One difficulty that we have had in trying to reproduce the right, left and forward excursions of the mandible was due to the interference of the occlusal rims, which had a tendency to dislodge the trial plates and give erroneous results. Attempts have been made to carve, or shape, the occlusal rims to harmonize with the mandibular movements. This can undoubtedly be done successfully in the hands of ingenious operators, but it is too lengthy and too difficult a process by which to teach beginners, and also the general practitioner.

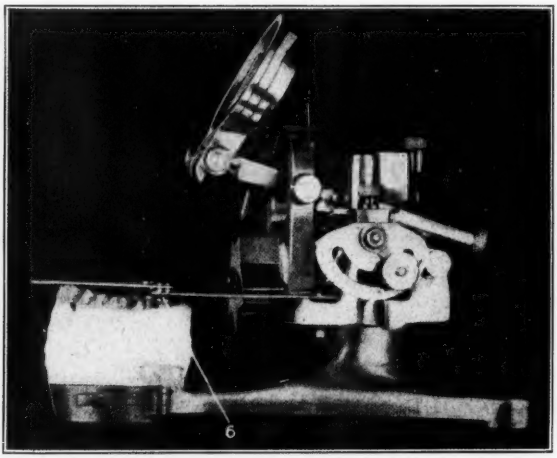


Fig. 3.—Relation of the occlusal plane to the mounting plane.

The graphic recorder, which I am about to describe, was designed to trace the Gysi gothic arch, and simultaneously record the inclinations of the glenoid fossa as a unit. Dr. Gysi, if I am not mistaken, was the first to secure tracings of the inclination of the glenoid fossa, and also of the gothic arch; but I am not aware of any previous attempt to combine these as a unit, and apply them, as such, in a simple, practical way, for full denture construction.

This difficulty is entirely overcome by the use of the central bearing idea; that is, when the upper and lower trial plates are held firmly against their respective ridges through a central bearing point, and held in perfect balance while the mandible is allowed to move freely in every possible direction without the slightest interference from the occlusal rims. Is not balance during function our ultimate aim in

denture construction? With this method we can obtain all the movements of the mandible under equalized stress conditions, which cannot be accomplished by any other means with the same degree of accuracy and ease of manipulation.

The graphic recorder consists of two flat metal plates having the general outline of the upper and lower ridges. One of these plates has an adjustable screw located near its center, with a smooth and well-rounded tip or point. This is intended to slide over the surface of its mate with the least amount of interference and friction. The plate carrying the gothic arch. To the lower recorder plate is attached a platform with replaceable cards on which the tracings are made.

The technic of its use is very simple: Casts and well-fitting trial plates are constructed, trimmed and adjusted in the usual way for the occlusal plane, bite length, fullness, etc. After this is done, sufficient wax is cut off from the lower trial plate to accommodate the thickness of the lower recorder plate, in order to maintain the same occlusal level and plane. It is very important that one of these recorder plates maintain the ultimate level of the occlusal plane. This

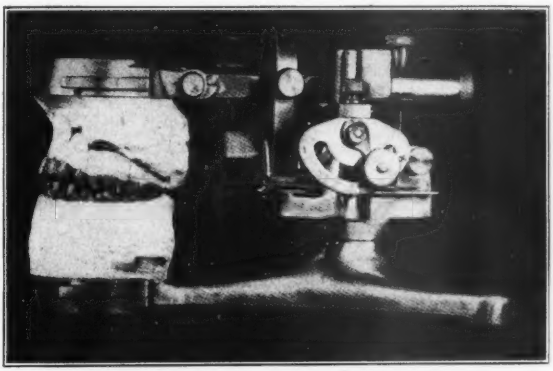


Fig. 4.—Both casts mounted in centric relation.

central bearing screw is preferably used for the lower jaw, but, in prognathous cases, it can be used for the upper jaw, should conditions indicate. These plates are called the upper and lower recorder plates. To the upper recorder plate is attached a cross bar which is supplied with three removable gothic arch tracers, each with a graduated plate, indicators and pencil points, which, while in use, simultaneously indicate the vertical displacement of the condyle in the glenoid fossa, and also make pencil tracings of the should be done with the lower recorder plate. Considerably more wax is then uniformly cut off from the upper trial plate, and the upper recorder plate is attached. The two trial plates with the recorder plates attached are then carried to the mouth in order to determine that the recorder plates are in full contact with each other, even though the bite is slightly closed.

As considerably more wax has been removed from the upper trial plate than is necessary to accommodate the thickness

of the upper recorder plate, the central bearing screw is adjusted to restore the proper bite length, and also to keep the two trial plates in balance and far enough apart, that, during the execution of the various mandibular movements, there will be no contact between the two plates other than at the central bearing point. It is not absolutely necessary to maintain the exact bite length, because, should the bite be slightly opened or closed, this condition can be remedied or readjusted on the articulator without disturbing the normal relation of the two casts, and each gothic arch tracer. After we have made sure that the pencil points of the gothic arch tracers are in contact with their respective cards, the indicators are freed, and, if necessary, readjusted, so that, when the patient holds his jaws together, the indicators remain stationary at zero.

The patient is now requested to hold his jaws together with sufficient pressure to keep the two trial plates firmly against the ridges, and as he moves his mandible forward and back, always to maintain that contact at the central bearing point.

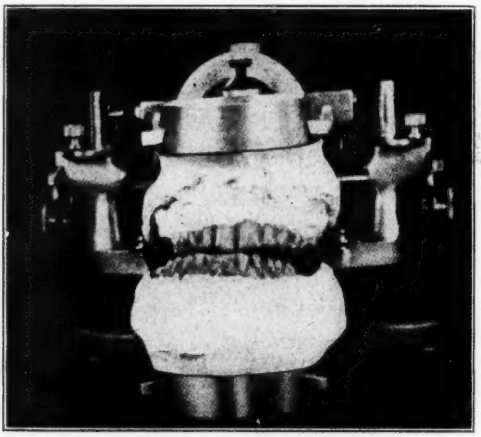


Fig. 5.—Locking mold method (not advisable when natural teeth are present).

without necessitating the remounting of the casts on the articulator.

The two trial plates having been adjusted so that they are free from interference with each other, the upper crosspiece and the lower platform are attached to their respective plates, and the gothic arch tracers, with the indicators locked at zero, are brought into contact with their respective cards, pencil points downward, and made fast. The zero mark is plainly seen on the graduated plate of

After a few back and forward movements of the mandible, the patient is instructed to describe alternately, forward, back, then right; and again, forward, back, then left movements, until a definite gothic arch tracing has been secured with the middle tracer. During these tracings, it will be noted that the tracing plungers or indicators move freely up and down with the movements of the mandible, above or below the figure zero on the graduated plate.

After a good gothic arch tracing has been obtained, the patient is asked to move his jaw to the extreme right position, and with his jaw held still, this position is marked on the card; also the relative position of the plunger, whether it be above or below the zero mark of the balancing side, is noted and written down on its respective card. This is repeated for the opposite side, and the records are complete. The trial plates with their attachments are then removed from the patient's mouth, and the indicators are locked again at zero.

Fig. 6.—Observation method. The articulator is adjusted for either lateral or forward positions by comparison with the teeth in the mouth.

An examination of the tracings on the cards will reveal that the middle tracing is the true gothic arch tracing, but the right and left tracings do not represent a true gothic arch. These help to determine the true relation of the heels of the upper and lower casts to one another, and also to indicate the exact amount of Bennett movement that the patient has during the lateral excursions of the mandible.

With a pointed instrument, a slight depression is made at the apex of the middle gothic arch, and the two trial plates are brought together, so that the middle pencil point rests in the depression made on the card, and the trial plates rest in contact with each other at the central bearing point. With this depression on the middle card as the pivoting point, the heels of the trial plates are moved to the right or to the left until the other two pencil points are brought in contact with the tracings which they have made, and at the junction of the two elliptic arcs which each has described. These appear almost as true gothic arches. Two more depressions are then made on the cards at these points, one on either side, where the pencil points have come in contact at the junction of the two elliptic arcs. In this way, the trial plates are held securely together, and in proper centric relation, by means of four bearing points; one, the central bearing point of the recorder plates, and the other three where the pencil points come in contact with their respective cards at the apex of the tracings. The depressions made on the cards will hold the two trial plates securely enough without the need of waxing them together while they are mounted on the articulator. There is no reason that we should not wax them together if we wish to do so.

The fact that these tracings have been taken under functional pressure eliminates all possible danger of change in the bite relations, due to the depression made on the cards. Any error caused by these depressions is too slight to be taken into consideration. At this time, it is advisable to retrace the gothic arch tracings with ink, so that they will not be obliterated during the mounting process, or

during the adjustment of the articulator.

With the records complete, the upper and lower trial plates are made secure to their casts with sticky wax before mounting on the articulator. The lower cast is always mounted first. Thus, we have the upper and lower casts mounted on the articulator in true centric relation to each other under true masticatory stress conditions, and we have the readings of the right and left lateral movements indicating the vertical displacement of the condyle in the glenoid fossa, and also the outermost tracings of the three gothic arches, which are to act as guides to the adjustment of the lateral controls of the articulator for the proper interdigitation of the cusps. In other words, we have a true and permanent graphic picture of all the movements as they have been executed by the patient.

The main purpose behind the development of the graphic recorder has been to simplify the process of recording mandibular movements by unifying them all into one single operation. Any articulator that can be adjusted with a reasonable degree of accuracy to reproduce these graphic records ought to be a very good instrument to use. I have no criticisms to offer regarding any of the adaptable or semi-adaptable articulators. If an articulator can reproduce the graphic records, if it can be easily adjusted and manipulated and will permit the opening and closing of the bite, without the necessity of remounting the casts, it should be a good instrument to use. It is the man behind the articulator, and not the articulator itself, that will determine the amount of success in the results obtained.

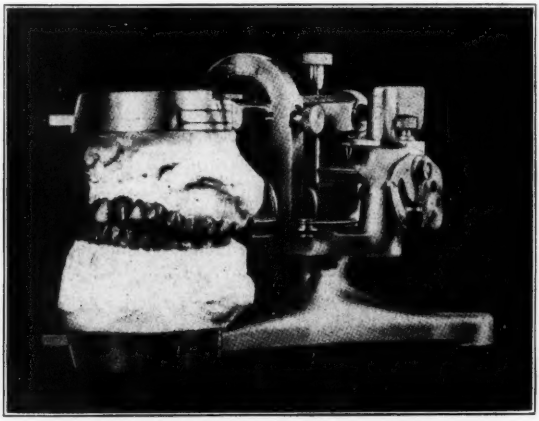


Fig. 7.—Observation method. (See Figure 6.)

The construction of the articulator which I am using is based wholly on the graphic records which are obtained with the method described above. It is easy to adjust and easy to manipulate, and possesses features which are not found in any other articulator as a group. It can be used as a rigid plane line articulator, as a semi-adaptable, and also as a fully adaptable articulator. It can be adjusted for a true retrusive position of the mandible after the casts have been mounted, in order to relieve cusp interference; and

also, without the necessity of remounting either of the casts after centric occlusion has once been obtained, the bite can be safely opened and closed as the case may be.

The Phillips pantographic articulator is essentially a pantograph limited to the range of the movements of the mandible. It is practically a mechanically controlled reproduction of the graphic recorder, as the upper or movable arm of the articulator is capable of retracing simultaneously one or more gothic arches, with the aid of two lateral controlling planes, and

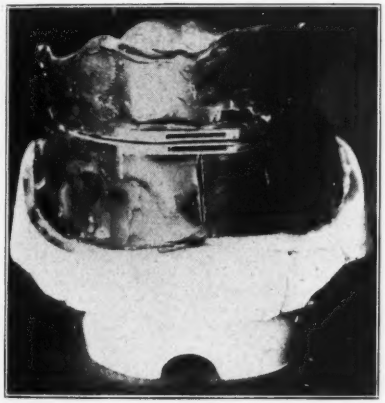


Fig. 8.—Trial plates with their respective recorder plates in position. The bite is slightly closed.

reproduces the horizontal inclinations of the glenoid fossa by two adjustable horizontal planes. Structurally and dimensionally, it is not a copy of the human skull. It therefore needs no facial measurements for its adjustment and the mounting of the casts. It consists of a base with a lower model holder or cup, and a floating upper arm with an upper model holding cup, and is connected to the base through a universal ball and sliding barrel joint. The upper arm is a crosslike affair resting on two adjustable horizontal planes by means of two vertical pins, and at dead center to the axis of the horizontal planes when in centric relation only. The connecting link between the upper arm and its base is located considerably behind the rotating axis of the horizontal planes, designed in such a way as to allow sufficient Bennett movement for the average case, and also to allow for opening and closing of the bite, without loss of the true relation of the casts to each other during the opening and closing movements.

Fig. 9.—Trial plates held apart at the proper bite length with the aid of the central bearing screw. (The arrow points to central bearing in Figure 13.)

The lateral movements of the arm are controlled by two horizontal pins resting against two vertical adjustable planes identical in construction with the two horizontal planes. When the upper arm is parallel with the base, both the horizontal and vertical planes rest against their respective pins at dead center to the axis of their rotation center. This is called the zero position, or position of centric

occlusion. The instrument is equipped with model holding cups to enable the operator to remove the models easily, and replace them with others. The upper model holding cup is attached by means of a hinge to the upper arm. When the upper arm, or the adjustable part of its mechanism, is locked into zero position, the instrument is converted into a rigid plane line articulator, but with the additional advantage of executing the opening and closing movements without any adaptable articulator. If the Bennett movement in a given case is considerably greater than the average, this connection can be adjusted to allow for all the play needed, as the case may be, converting the instrument into a fully adaptable articulator. At the hindmost end of the upper arm is an adjustment which, when locked, maintains the true centric relation of the casts, and when loosened, allows for the retrusion of the mandible along the plane of the condylar inclinations.

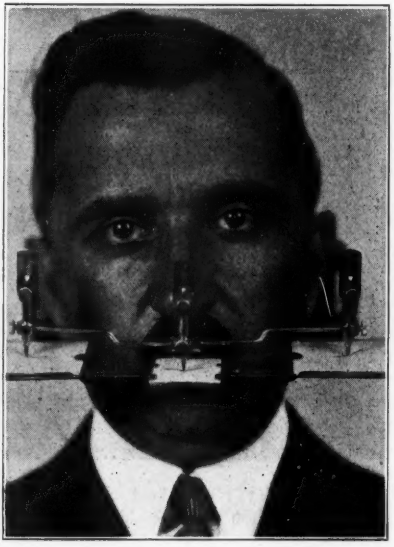


Fig. 10.—The graphic recorder after tracings have been made. The pencil tracings have been retraced with ink.

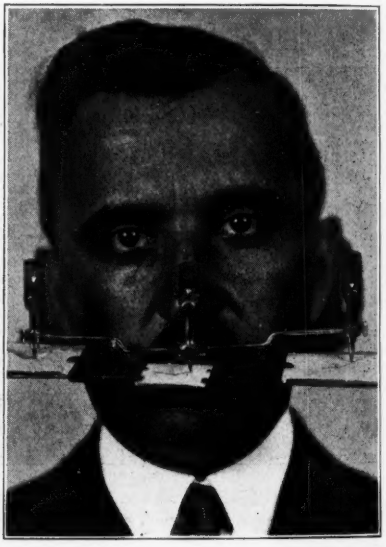


Fig. 11.—Right lateral position. The plunger on the working side is five gradations above the zero marking; the balancing side is four gradations below the zero marking.

cusp interference at the heels or molar region.

The vertical pin, which is located at some distance behind the axis of rotation of the horizontal planes, and serves as the connecting link and control between the base of the instrument and the upper arm, if held in a rigid perpendicular position, converts the instrument into a semi-

Dr. Orton, of the University of California, after long experimentation, has developed a roentgen-ray technic by which he has clearly shown, in hundreds of cases, the relative position which the condyle assumes in the glenoid fossa, when the distance between the upper and lower ridges is increased or decreased;

that the change takes place in the position of the condyle along the inclination of the glenoid fossa, and that the forward and backward movement of the condyle is determined by the degree of inclination of the glenoid fossa, and also by the thickness of the intervening fibrocartilage.

In this instrument, should one attempt to open or close the bite, it will be noted that the vertical pins of the upper arm will travel away from the center of rotation of the horizontal planes, either forward when the bite is open, or backward when the bite is closed, which is exactly what happens in the temporomandibular joint when the distance between the upper and lower ridges is increased or diminished. That this ought to be so theoretically is proved by Dr. Orton's experiments. That it is so has been demonstrated in all practical cases when the bite has been deliberately opened, in some instances more than one fourth inch, after the casts had been mounted in centric relation. It is needless to say that the opening and closing of the bite should not be attempted until after the condylar inclinations have been determined and adjusted.

Fig. 12.—Left lateral position.

The casts are always mounted in centric relation, the lower being mounted first, and with the aid of the mounting plane. The mounting plane, when in use, forms an equilateral triangle with its apex at the median line of the instrument. The casts should be centered within this triangle with the median line of the casts coinciding with the median line of the instrument. For mechanical reasons, owing to the construction of the instrument, the incisal portion of the trial plates should be in contact with the mounting plane, and the heels lowered from 10 to 15 degrees from the under surface of the mounting plane. After the lower cast has been mounted, the upper cast is placed in proper centric relation to the lower; the instrument is locked into zero position, and the cast is attached to the upper arm.

After the casts for a set of full dentures have been mounted with the aid of the graphic recorder, the indicators of the gothic arch tracers are released, the instrument is unlocked and all its adjustments are thrown out of interference. The upper arm is then carried along the gothic arch tracing to the right, and the right lateral control plane is brought in contact with its corresponding pin, and is made fast. If the upper arm should then be allowed to slide back from the extreme position, it will retrace accurately that side of the gothic arch, until it reaches centric position.

The procedure is repeated for the other side. It will be recalled that during the taking of the records, the vertical dis-

placement of the gothic arch tracers for the balancing right or left positions had been written down on their respective cards. To adjust the instrument for the horizontal inclinations, the upper arm is again carried along the balancing or outer arc of the gothic arch until it reaches the end of the tracing. Then, the horizontal plane, on which the upper arm rests, is raised or lowered until the same reading that has been obtained during the record-

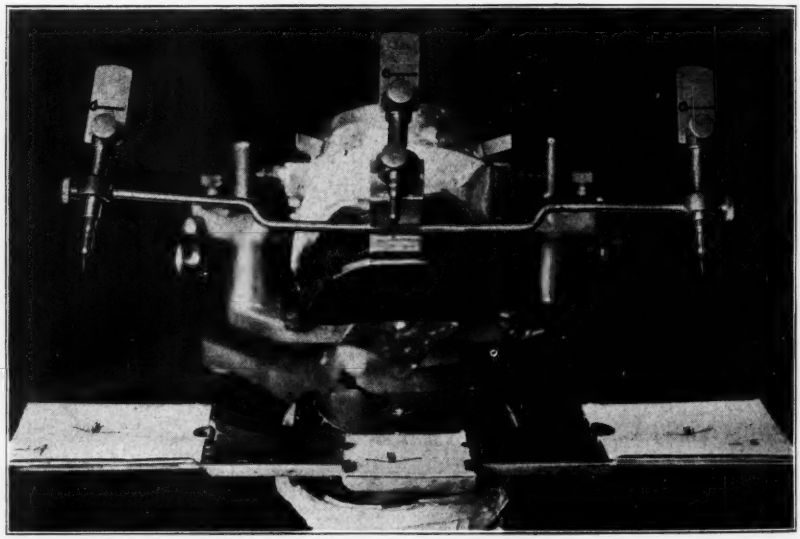


Fig. 13.—Casts mounted. The arrow shows the central bearing screw. The readings of the balancing position only are written on their corresponding cards as (–4) and (–5).

taking process is reproduced by the indicator. It is then locked in that position.

The procedure is then repeated for the other side. The instrument having been adjusted, the upper recorder plate with its attachments, and also the lower platform, are removed, but the lower recorder plate is left on the occlusal plane, and this is used as a guide on which to arrange the upper teeth. The teeth are arranged when the instrument is adjusted as a plane line articulator, and it is only after the full arrangement of the upper and lower teeth that the instrument is converted into a semi-adaptable or fully adaptable instrument for any rearrangement of the teeth for balance. With the instrument locked in centric or zero position, there is no danger of closing the bite. Occasionally, the bite can be opened slightly to allow for grinding, but that is left to the discretion of the operator.

As the casts can be removed and be replaced on the articulator at will, it is advisable that, as soon as the articulator is adjusted, its adjustment readings be dotted down on the casts for future use, in order that the articulator may be available for as many cases as the operator or technician might want to carry on.

The use of the graphic recorder in connection with taking impressions will be fully described in an article in one of the dental journals in the very near future. A brief description of the technic will not be out of place at this time.

Good modeling compound impressions of the upper and lower jaws are taken and artificial stone casts made. From these casts, and with the aid of thin aluminum trays, without holders, two modeling composition trial plates are made.

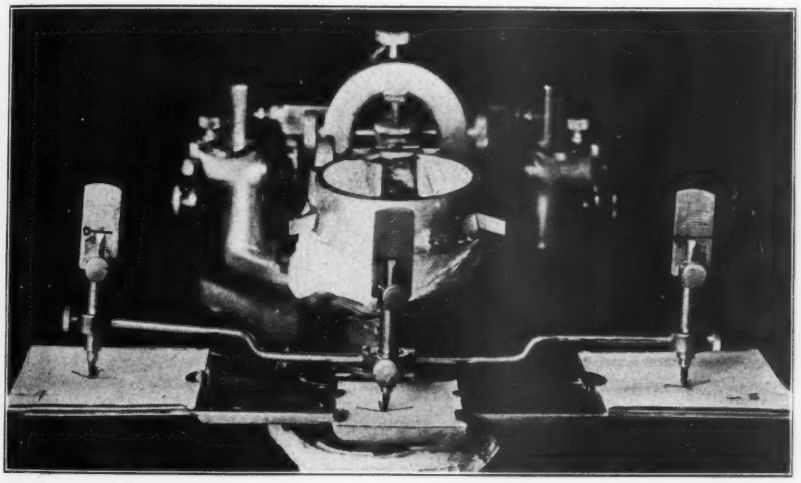


Fig. 14.—Casts in centric position; also plungers at zero markings.

These are muscle-trimmed and corrected in the mouth by the correctable impression method. Their occlusal portion is then trimmed and adjusted for fullness, bite, etc., and the recorded plates inserted as for the graphic recorder technic.

Before the taking of the graphic records, both of these trial plates are lined with melted paraffin and inserted in the mouth, and the patient is instructed to go through very short-ranged chewing movements for several minutes. The plates are then removed and examined, and are lined again with paraffin. At this time, while the second coat of paraffin is being slowly molded in the mouth, the graphic records are taken. In this way, instead of having to mount casts, the operator mounts actual impressions, taken under the most accurate stress conditions obtainable, which are maintained throughout the construction of the dentures, owing to the fact that the graphic records have also been taken simultaneously and are true to stress conditions.

My reasons for advocating such a technic whenever indicated are stated in detail in an article entitled "A Workable View of Function in Denture Prosthesis from the Standpoint of Health and Prevention."[1]

483 Beacon Street.

1. Phillips, G. P.: J. Dent. Res., 8 (April) 1928.

DISCUSSION

Rupert E. Hall, Chicago, Ill.: The graphic registrations advocated by Dr. Phillips are records of movements of the mandible in two dimensions, the third dimension, that of the opening movement, not being included. Therefore, these registrations do not apply when teeth with cusps are inserted, and the patients use, as they do, the opening movement. For this reason, the registrations demonstrated by Dr. Phillips are not complete and are not acceptable. A further discrepancy is noted in that the apex of the gothic arch is assumed to be the functional centric relation of the mandible by and from which the registrations are made. If this point is not the functional centric relation, the records are wrong when using this point as a basis for registrations. (Compare Hall: "Full Denture Construction," "An Analysis of the Work and Ideas of Investigators and Authors of Relations and Movements of the Mandible" and "An Analysis of the Development of the Articulator," THE JOURNAL, July and September, 1929 and January, 1930, respectively.) I do not consider the procedure advocated by Dr. Phillips to be scientific or practical. The opening movement must be included in the registrations and the functional centric relation must be used as the basis for measurement. I have done considerable work in testing mandibles for functional centric relation and find that a great percentage of cases have for their functional relation a very different point from that indicated by the apex of the gothic arch, one case varying from this point to the very surprising extent of seven thirty-seconds inch. A report on this work is given in my article, "Full Denture Construction."

F. M. Hight, Houston, Texas: The problem of registering mandibular movements and their reproduction in an instrument is without doubt the most difficult that the denture worker has ever faced. Many beautiful but theoretical pictures of how this could be done have been given to the dental profession in the last eighteen years, but the gap between theory and practice has not been filled. The central bearing point as given us by Dr. Phillips is without doubt a step forward in securing correct registration of jaw positions. The problem is not so easily solved as Dr. Phillips would lead one to believe. The registrations as made by his technic are in one plane, and

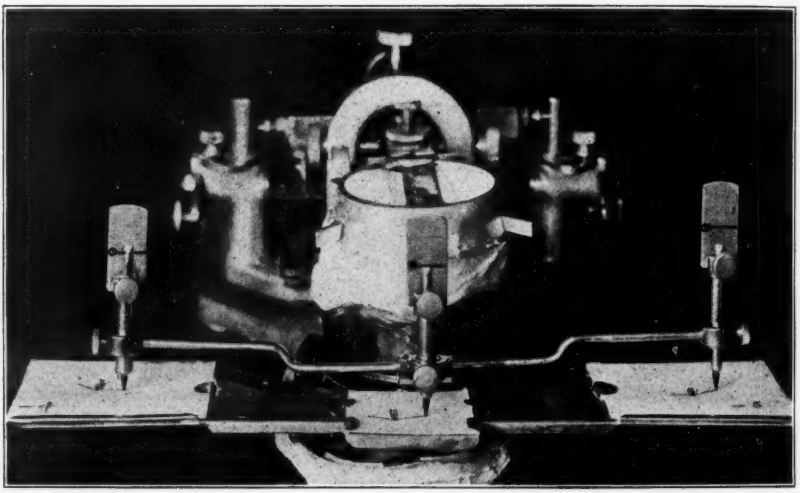


Fig. 15.—Articulator adjusted for right balancing position. The plunger at the left indicates (–5). This is the reading for the balancing side. The working side is ignored.

I believe that if it were possible first to arrange the anterior teeth which would give the amount of overbite for a given case, the technic would give better practical results. I am glad to see that one who has given so much of his time to the study of this problem recognizes the apex of the gothic arch as the point of true centric relation of the jaws and that this must be our starting point if we are to use cusps on the teeth. We should not confuse centric relation with a relaxed relation. True centric relation is a strained position in most cases because it is a functioning position, and not one of rest. The problem of correctly arranging the teeth to conform to these movements after they have been registered is one that requires a great deal of skill. The common practice today is to grind the teeth after the dentures are finished, until they balance, which, in most cases, eliminates the cusp, because they were incorrectly arranged. There is one point of great importance in this full denture work that should be adhered to and that is removal of the denture and cast intact from the vulcanizing flask and replacing to the original position in the instrument by means of a plaster seat and spot ground for even contact in centric relation. If we find that we are making an error, it is best to finish the upper denture first and rearrange the lower teeth while they are still in the wax. Because of the failure of wax or compound checkbites to register lateral position of the mandible correctly, in the hands of most of us, the technic employed by Dr. Phillips should be given a fair trial.

Victor H. Sears, New York City: From the theoretical standpoint, Dr. Phillips is entirely right in his thesis. From a practical standpoint, it really doesn't make so much difference whether we make graphic or other kinds of records or whether we make them intra-oral or extra-oral. At this time, I merely wish to voice my opinion on needlepoint tracings. That is a thing about which there should at this time be no doubt whatever. To my mind it is unfortunate that Dr. Hall should take the stand he does because the proof which he gives on the blackboard here, which is a reiteration of the arch he refers to in THE JOURNAL, is wrong from the standpoint of high school geometry. There is no such thing as arcuate movement of the mandible when the mandible is in true centric relation as defined by many men, who agree substantially as to that thing. If the patient is capable of making a needlepoint tracing, having the stylus at this angle, that does not say that he is incapable of making another arcuate movement within that angle, which he actually does. The point to remember is this: The arcuate movement is incorrect, and this movement as represented by the needlepoint tracing is the correct one.

M. M. Schwartz, Jersey City, N. J.: Our greatest difficulty in prosthetic dentistry is the fact that we are discussing instruments, materials, articulators and technics, but we do not get down to fundamental principles. We cannot develop articulators and technics unless we first establish fundamental principles. If we accept fundamental principles, we can then build instruments and establish materials and technics that will not violate the principles that have already been established. Dr. Phillips states that we must have fundamental principles, and that they must not be violated. Yet, in taking his records, he violates one of the most important fundamental principles. It has been definitely shown, demonstrated and proved by thousands of cases that the first fundamental principle of taking records is that we must have records unstrained if we wish to mount casts on an instrument. That is one of the principles that Mr. Hanau has given to us and it remains as the acceptable principle. In using the central point of contact, not only Dr. Phillips but also Dr. Stansbery and others who use that particular mode of taking records, believe, I presume, that one point of contact will cause an equal distribution of pressure throughout the area while the patient is making a mandibular movement. If we have gas within a tank and we apply pressure on this gas at any one point, the pressure will be equally distributed throughout the gas. The same holds true of liquids; but with solids, that law does not hold: We have different densities to consider, and with different densities, the pressure is not applied equally throughout the entire mass. Therefore, if we have a single point of contact, we find that, though we may obtain the correct position of the mandible by using the tracing device, we will not get the position of the mandible without strain. Let us assume that we are standing in the middle of a log, one point of pressure thus being applied right in the center, and under this log is quicksand. As that log goes down in the quicksand, it goes evenly because the quicksand is soft throughout its entire

mass. Then let us assume that after it gets down some distance, one end meets a rock. As we are still standing in the center of the log, the pressure is still transmitted at the central point. The moment the log hits the rock, which is harder than the quicksand, it ceases to sink at that point, but otherwise continues sinking. Even if we had one point of pressure, therefore, in the course of varying densities, we do not have an unstrained or equal distribution of pressure throughout. There will always be a tipping. Since we have soft tissues in the mouth, and some other tissues are somewhat harder, even though we apply pressure at one point to equalize that pressure, wherever the tissue is softer there is a tipping of the occlusal rim; and if we take the record in that matter, mount the casts that way on the articulator and set the teeth, we find, on going back to the mouth, that because we have applied pressure, even though it was at one point, the teeth do not occlude properly in the mouth. In that respect, I believe the fundamental principle of unstrained record has been violated in using the strained tracing for the original mounting. There is a place for the tracing device. If we first take an unstrained record and mount our casts with this record, we can then use the tracer as a check on the position of the mandible. Strain cannot be checked with the present tracing devices.

C. J. Stansbery, Seattle, Wash.: If the denture hits a rock, i. e., a hard place on the ridge, and there is a soft place beside it, we want that denture to equalize the various resiliencies which pressure will give it. I can't see Dr. Hall's point of a single axis, but I can see a variance from the horizontal plane of Gysi for rotational center toward the single axis. It goes toward the single axis.

Dr. Phillips (closing): The reference which Dr. Schwartz makes to the log and quicksand seems to be rather far fetched. No engineer will ever attempt to build on a foundation of variable resistance until he has equalized the distribution of the load of his structure. This is what we accomplish with the central bearing method. Referring to Dr. Hall's comment: Had he taken a little more time to analyze this method and understand its application, he would have seen that the third dimension about which he spoke is a lost factor in full denture construction, which we have to supply. The graphic records do not supply this dimension but determine it. We have to supply it when we select the teeth. The graphic records are simply records which automatically determine the range within which we have to work. His complacent state of mind, apparently due to a notion that he has solved everything by simply ignoring facts, makes me feel like a sinner in a revival meeting refusing to be saved.

FOOD IMPACTION*

By ISADOR HIRSCHFELD, D.D.S., New York City

THE biologic tendency toward self-preservation is always an interesting study. To the periodontist, it becomes an absorbing one, as he observes how tissues, given the proper impetus, tend to more or less successfully fight off traumatizing agencies, be they bacterial, chemical or mechanical. He has frequent opportunity to note the unfailing definiteness with which diseased periodontal tissues come back to normal, step by step, in a degree corresponding to the thoroughness of the removal of traumatizing conditions in each successive operation. The efficient elimination of these condi-

*Read before the American Academy of Periodontology, Washington, D. C., Oct. 4th, 1929.

*A contribution to the annual report of the Committee on Scientific Investigation of the American Academy of Periodontology.

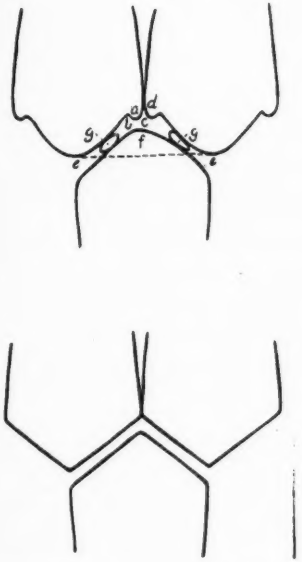


Fig. 1.—Above: Diagrammatic drawing of a longitudinal section of unworn bicuspids. The occlusal aspects consist of a series of convexities which require minimum pressure for crushing of food (*g*), thus minimizing the tendency to wedge the teeth apart. *d* and *e-e*, the major occlusal embrasure into which food is packed by the opposing plunger cusp (*f*); but the food is prevented from entering the interproximal space by the marginal ridge, the incline of which, arising from the bottom of the marginal groove (*b*), steers the food occlusally. (The pressure of food between this incline and that of the marginal ridge of the opposing tooth is a lesser factor in keeping the adjacent teeth in contact during mastication.) *c*, minor occlusal embrasure bounded by the crests of the marginal ridges (*a*) and the contact point (*d*). **Below:** Diagram showing that when the original convexities are worn down by occlusal wear into large oblique facets opposing each other, a powerful wedging contrivance is formed. Furthermore, the elimination of the marginal grooves and ridges permits the packing of food into and through the resultant occlusal opening. This action is augmented by the close following through of the sharp point or edge on the plunger cusp.

tions is usually not difficult, once their identity is ascertained, and a complete recovery may, therefore, be expected in healthy individuals, and often in unusual cases.

Unfortunately, in many instances, because of failure to recognize causative conditions, timely help is not given, and the tissues, struggling against odds, may ultimately be destroyed. This is especially true in the case of food impaction. Its existence may, in most instances, be recognized readily enough, but the anatomic abnormalities directly or indirectly responsible for it remain unidentified and therefore are not remedied. The rôle of food impaction, frequently a dramatic one, has not received, to the best of my knowledge, consideration in dental literature commensurate with its importance.

DEFINITION

Food impaction is the forceful wedging of food through occlusal pressure into the interproximal spaces. This term may also be applied to a similar, although much less frequent, forcing of food into the buccal or lingual gingival crevices, but should be differentiated from the less forceful action of the tongue and the buccal parietes in depositing food in these spaces and crevices. In the latter action, the food produces no mechanical injury and can be easily removed by ordinary brushing and rinsing.

PATHOLOGY

Food impaction, because of its persistence and untoward effects, immediate and ultimate, is frequently a source of extreme annoyance to both the dentist and his patient. A closer study of this subject will no doubt show that the incidence of dental and periodontal disease inaugurated by food impaction is far greater than is generally appreciated. The ill effects due directly or indirectly to

food impaction are as numerous as they are diversified. They may be listed as follows: 1. Discomfort caused by interproximal pressure and pressure against the septal tissue. 2. Local pain caused by superficial and deep proximal caries. 3. Neuralgic reflex pains at more remote points. 4. Chronic hypertrophic gingivitis. 5. Hemorrhage. 6. Susceptibility of septal tissue to acute infection and reinfection through lowered resistance. 7. Alveolar and gingival recession. 8. Chronic pericementitis. 9. Acute pericementitis. 10. Elongation of the tooth. 11. Drifting. 12. Traumatic occlusion. 13. Suppurative periodontoclasia. 14. Local acceleration of an existing periodontoclasia. 15. Retardation of progress in treatment of periodontoclasia. 16. Root exposure. 17. Hypersensitiveness of the root surface. 18. Presence of deep cervical proximal caries, frequently overlooked until too late and usually very difficult to mend. 19. Probable infection of the pulp and serious local or systemic consequences. 20. Loss of the tooth.

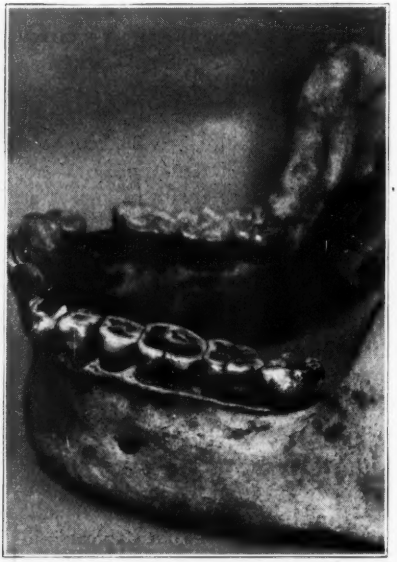


Fig. 2.—Mandible of Australian aboriginal. In contrast to Fig. 1, *B*, the occlusal wear is horizontal and, therefore, a wedging process is improbable. Proximal contiguity is constantly maintained during function, and food impaction is not likely to take place. There is marked proximal wear. (Photographed at the American Museum of Natural History.)

ANATOMIC MECHANISM FOR PREVENTION OF FOOD IMPACTION

In a consideration of functional and protective anatomy of the masticating apparatus, one finds that the mechanism of the ensemble of anatomic factors in the prevention of food impaction is as interesting as it is ingeniously complicated. Clinical experience proves that a devia-

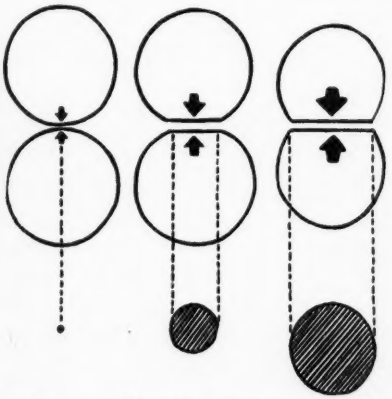


Fig. 3.—Mechanical equation upon which the dynamics of the wedging process is based (see text). Left: Minimum pressure required to crush a substance between two convexities. Center: Moderate increase in pressure required with the convex areas worn into small facets. Right: Correspondingly great pressure required with the further increase in the size of the facets. It is obvious that with such facets worn on the oblique occlusal planes, a powerful force tends to wedge the teeth apart.

tion from the normal in the character or arrangement of any of these affords an opening for impaction. If the comminuting part of the masticating apparatus were one continuous structure, there would probably be few if any problems due to food impaction. But Nature has evolved instead a contiguous arrangement of small individual units which, although they function as distinct entities, are nevertheless dependent on their contiguity for better physiologic efficiency and for mesiodistal support against masticatory strain.

Just as these units, the teeth, are built structurally to withstand hard strain and wear, so are they molded to achieve maximum chewing efficiency and to prevent possible incidental mechanical injury to their supporting structures. As food impaction is one of the most formidable agents in producing such injury, it is interesting to note how the following anatomic features are constructed to ward it off.

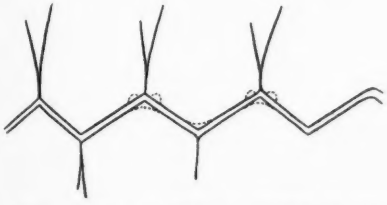


Fig. 4.—Class I, Type A, method of correction. Marginal grooves are ground into the tooth substance with burs or sharp mounted stone wheels. This serves two purposes: (1) to restore the advantages derived from a marginal groove and ridge in the prevention of food impaction, and (2) to reduce the facets. The cusps are shortened, which gives additional similar advantages. The facets are thus reduced to about half their original size. One need not fear the breaking (through masticating strain) of the artificially produced marginal ridges if they are judiciously made. If this does occur, it is still possible to rebuild the tooth through inlays, which was the other alternative in the first place.

Contiguity—Contact Points. — The efficiency with which the contiguity of the teeth, normally constituted and maintained, serves to protect their surrounding tissues against food impaction depends on the proper location of the points of contact, their size or form having little or no effect. It is beyond my province to try to determine whether Nature placed the contact points at the ends of the longest mesiodistal diameter of the teeth or the diameter was extended between these contact points through evolution,

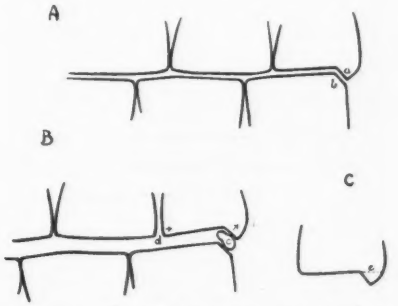


Fig. 5.—Class I, Type B. *A:* *a* and *b*, opposing oblique facets, which are the offending factors. *B:* Wedging process produced by these with tenacious food (*c*) as an intermediary. This results in an occlusal opening at *d*. *C:* Simple method of eliminating the wedging process by removing the overhanging partly worn cusp at *c*. The elimination of this point produces practically no disadvantage.

but it is obvious that this arrangement has definite, vital advantages, some of which are the following:

A. Buccolingual location: 1. With contact points normally located in the buccolingual direction, we are likely to have, during mastication, a proportionate physiologic strain (compression or pull)

per area unit on the buccal and lingual parts of the periodontium, especially the pericementum. When a tooth stands buccally or lingually to the arch, an abnormal condition obtains in which the points of contact lie either buccally or lingually to the mesiodistal diameter, and the buccolingual strain on the periodontium is disbalanced. On one side, that tooth is limited in its range of movement by its neighbors; while, on the other side, it may be forced beyond the normal distance on account of an inharmonius occlusal relationship due to its malposition (Figs. 32 and 33). This abnormal distribution of pressure gives rise to biologic disadvantages accruing from hypofunction or hyperfunction, respectively.

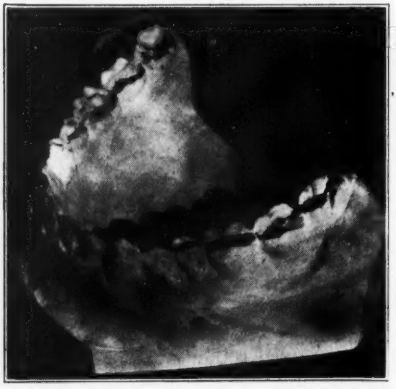


Fig. 6.—Advanced occlusal wear of the mesial cusps of the lower left third molar. This permitted the tooth to extrude out of the socket with the unworn distal cusps projecting beyond the occlusal plane, distally from the upper second molar.

2. In an instance like the foregoing, when the malposed tooth is moved still farther out of the arch during mastication, the contact points may be opened to food impaction. This is not likely to occur in the normal arch except where the contact points are similarly misplaced through improperly contoured restorations.

B. Cervicoclusal location: It is obvious that, in this dimension, the longest mesiodistal diameter, with its poles as contact points, is placed as close to the crest of the marginal ridge as possible without limiting the physiologic morphology of that anatomic character. The outstanding advantages of this arrangement are:

1. A larger interdental space above the alveolar crest. This permits of greater bulk to the interproximal papilla and thus provides more efficient vascular equipment. To a periodontist, such an advantage is self-evident, since he constantly meets with various pathologic conditions specifically focused in this tissue. In contrast, when the point of contact approaches the alveolar crest, the interproximal space and papilla are cor-

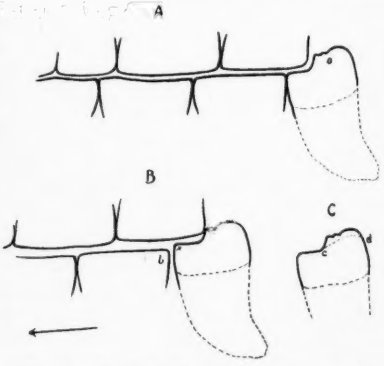


Fig. 7.—Class I, Type C. *A: a,* extruding unworn cusps which in *B* is thrust backward by the upper second molar when the mandible is brought forward. In addition to the severe traumatic occlusion thus produced, the interproximal space is opened at *b,* which invites food impaction. *C:* temporary correction by grinding the cusp down at about the line *c-d.*

respondingly small. Consequently, the vascular equipment is dwarfed and has, therefore, difficulty in disposing of the increased influx of blood due to inflammation. This condition, supplemented by the constricting action of subgingival deposits upon the blood vessels, results in partial strangulation and its accruing disadvantages.

2. Minimum depth to the minor occlusal embrasure: The cervicoclusal location of the contact points decides the depth of the minor occlusal embrasure, which is bounded occlusally by the crests of the marginal ridges. (Fig. 1, *A*.) For practical purposes, this embrasure may be considered as a small wedge-shaped funnel into which, driven by occlusal pressure, food is directed and compressed, and through which, under abnormal conditions, the food is forced into the interproximal space. The deeper the funnel, the greater the tendency to food impaction. (Figs. 12 and 28.) It is evident, therefore, that everything being equal, the nearer the contact points are placed to the occlusal plane, the less the tendency to impaction.

MARGINAL RIDGE AND GROOVE

The extra-oral factor, food, through its bulk and tenacity, becomes the indirect physical means through which the dynamic forces of mastication may effectively wedge teeth beyond their normal range and thereby cause the opening of interproximal spaces. The mechanics of this action may be thus explained: As the mesially and distally inclined planes of the cusps of adjacent teeth converge toward each other, they form a larger funnel than the one mentioned above, which may be termed, in contrast, the major occlusal embrasure. (Fig. 1, *A*.) As a result of the normal interdigitating mesiodistal arrangement of occluding teeth, the cusp opposite this funnel assumes, in the presence of food, the rôle of a wedge tending to force the teeth apart. As these planes become worn and produce facets in place of the former convexities, the pressure surface area be-

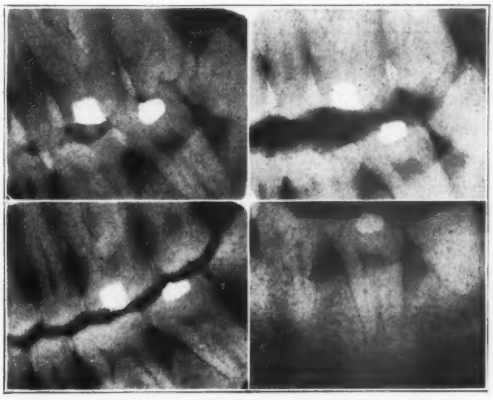


Fig. 8.—Case shown in Figure 6; left, above, in centric and, below, in eccentric occlusion. Right, the same, after the reduction of the distal cusps.

comes greater and, consequently, the wedging force is stronger. (Figs. 1, *B*, 3 and 4.)

A similarly increased wedging force may obtain where cusps are abnormally long and the incline of their planes is accordingly steeper (Fig. 30). It is easy to understand that the opposing cusp, by virtue of its position directly opposite the occlusal embrasure, may, simultaneously with its wedging action, act as an effective plunger, which, under certain conditions, may force food down into a temporarily opened interdental space. We may, therefore, refer to cusps thus situated as plunger cusps. The function of the marginal ridge and groove is to prevent this wedging and packing action, and they seem to be specifically designed for this purpose. Located as they are at the bottom of the major occlusal embrasure, they cut off the funneling pressure to a minimum through the steep rise of the ridge from the depth of the groove which redirects the food occlusally.

If the marginal ridge and groove are omitted in restorations such as fillings and crowns, food impaction is likely to follow except in teeth in which the entire occlusal surfaces have been worn down horizontally. In such a case, there is no wedging action if contiguity is at all maintained, and there is no functional necessity for either the marginal ridge or groove as far as food impaction is concerned (Fig. 2). On the other hand, when the cusps are worn obliquely and the groove and ridge are also obliterated, impaction is very likely to take place in spite of normal contiguity and a full complement of alveolar support.

The groove and ridge maintain this preventive function only as long as the tooth retains approximately its normal axial position and its occlusal plane in the arch. For instance, where, through some disarrangement in the arch, such as mesiodistal tilting or extrusion due to a missing opponent, the clinical contact point of a tooth is moved quite a distance cervically, the marginal groove and ridge

Fig. 9.—Concavity on the summit of the upper right cuspid. After the clearing up of the subacute Vincent's infection, the septal gingiva between the lower right cuspid and first bicuspid was still inflamed and bleeding, evidently owing to the food impaction caused, in part, by the described concavity.

Fig. 10.—Food impaction between the upper left cuspid and first bicuspid. The opposing plunger cusp not only extended deeply into the funnel, but also presented a concavity.

are too far removed from the contact point to aid in the prevention of impaction (Class 2, Types B and C).

For the benefit of those who may be especially interested in the anatomic form and location of the contact points and the marginal ridge, I will quote briefly from M. Diamond's "Dental Anatomy":

> The marginal ridges are definitely designed to stand guard against the impaction of foods in the interproximal spaces. Rolled over toward the occlusal surface and slightly elevated above the central groove, their function is to keep the foods within the area of the occlusal surface very much as the rim confines the contents of the saucer. . . . The tendency is to place them too high in relation to the summits of the cusps, shortening the arms of, and limiting the action of the cusps which bear the entire brunt of the function of mastication. Their position, however, can be definitely determined. The marginal ridges are no more than a millimeter occlusally above the central groove which is the depth of the cusp. The point of contact in the region of the widest mesiodistal diameter is slightly cervically below the depth of the cusp. The distance between the point of contact and the marginal ridge is on the lesser side of two millimeters, with the depth of the cusps lying on a plane about midway between the two. The marginal ridge lies on a plane in between the depth of the cusp and the summit of the cusp, but close to its depth, with the summit of the cusp reaching generously about it.

Fig. 11.—Model shown in Figure 10, presenting the concavity on the cusp of the cuspid and the extent of reduction of the cusp as indicated by the pencil marking.

In addition to the three basic elements concerned in the prevention of food impaction, namely the contiguity of the dental arch, the location of contact points and the presence of marginal ridge and groove, there are a number of minor morphologic factors which individually or collectively are accessory. These will be alluded to later.

ETIOLOGY

At this point, we are ready to analyze the various anatomic mechanisms that cause food impaction and to study methods of procedure in their prevention and correction. Numerous instances may be seen in which the continued filling and refilling of proximal cavities, inclusive of properly constructed contacts, marginal grooves and ridges, failed to eliminate the impaction until some, perhaps remote, slight anatomic defect had been corrected. Such occurrences point to the importance of a serious consideration and intensive study of the abnormalities which lead to the inauguration of food impaction.

Instead of dwelling at length on the individual elements, such as lack of mesiodistal contact or support, various abnormalities in contour and relative position of the teeth, etc., I shall attempt to describe these in certain characteristic combinations, which form typical mechanisms that may be recognized repeatedly during the course of every-day practice. For convenience in recording, I have classified these types of mechanisms that produce food impaction, on the basis of their etiology, as follows: Class I Occlusal wear. Class II Loss of proximal support. Class III Extrusion of a tooth beyond the occlusal plane. Class IV Con-

genital morphologic abnormalities. Class V Improperly constructed restorations.

These are subdivided into constantly recurring types, of which there are numerous subtle modifications. I shall endeavor to describe the various types in each class and to suggest methods for their correction.

Various means are available for the correction of food impaction. In general, they include grinding, interlocking, rebuilding by means of inlays, orthodontia, tooth extraction and reconstruction of faulty restorations. The method and procedure suited to the individual condition can at times be selected very easily, but, in some cases, require special deliberation.

In my experience, grinding is the process most frequently indicated. Where its use is contemplated, one must exercise the same judgment as in its employment for the relief of traumatic occlusion; namely, confidence in its effectiveness and assurance that new complications, such as sensitiveness of the teeth ground or traumatic occlusion at perhaps some remote point, will not be initiated thereby. The other methods will be brought out

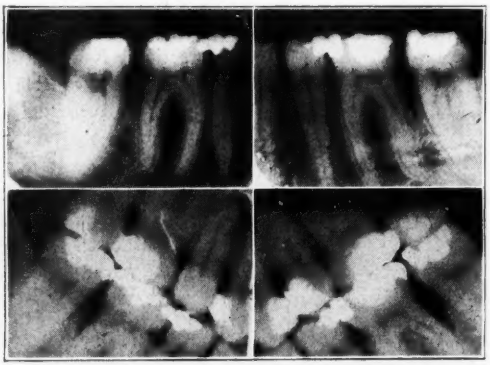


Fig. 12.—Condition following the extraction of the lower third molars. Food impaction was inaugurated immediately between the lower first and second molar on each side. The sudden loss of this distal support was the signal for the distal wedging of the second molars. This was facilitated especially by the abnormal form of these teeth, in which the contact points were too far removed from the occlusal plane. (Compare Class IV, Type B.) Above: Permanent space caused by the wedging process. While the second molar is the one especially moved by the impaction, its periodontium, including the gingival attachment, was entirely intact. At the same time, pocket formation and alveolar destruction is confined strictly to the mesial part of the septal tissues. (These observations may be made very frequently in this type of food impaction mechanism.) The reduction of the alveolar process is probably produced by a steady pressure of the food in the mesial direction brought on by the mesial recoil of the posterior tooth in its tendency to return to its normal position on the cessation of occlusal pressure. Below, left: Food impaction was completely eliminated through the artificial building out of contact points close to the occlusal plane by means of occlusoproximal inlays. Accordingly, the pyorrheal condition responded promptly to routine treatment. Below, right: On this side, although the dentist reestablished contact, he failed to raise the points near the occlusal plane. Food impaction, therefore, continued, which prevented the healing of the pocket.

in connection with specific instances later in the paper.

CLASS I: OCCLUSAL WEAR

We frequently see reference in dental literature to occlusal wear as an approach to a more harmonious occlusal relationship in function. Close observation will bear this out, but, by the same token, occlusal wear, when marked, is often not without its physical disadvantages, such as food impaction and traumatic occlusion. The outstanding types of food impaction mechanisms caused by occlusal wear are as follows:

Type A: Wedging Action Produced by the Transformation of Occlusal Convexities into Oblique Facets (Figs. 1, B and 4). This type has been referred to earlier in the paper. The original convexities and grooves of the mesiodistal planes of the occlusal surfaces, inclusive of the marginal ridges and grooves, are completely defaced, and only sharply outlined cusps remain, with gross mesiodistally inclined facets. These cusps interlock very closely with their opponents, and thus a most powerful wedging mechanism is produced the dynamics of which may in part be thus explained (Fig. 3): Given the pressure per area unit, the total pressure required to crush or penetrate a substance equals the unit pressure multiplied by the total pressure area. In other words, the larger the pressure area, the greater the pressure required to penetrate or crush the substance. Thus, as the various convex areas on the mesiodistally inclined occlusal planes are fused into large oblique facets, and masticatory pressure is accordingly increased, adjacent teeth tend to be easily wedged apart by the opposing, similarly worn plunger cusp. The result is an occlusally open interproximal space. The intensity of

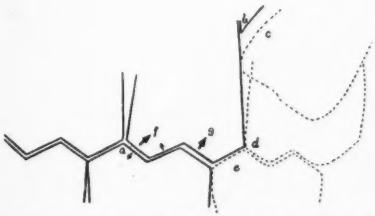


Fig. 13.—Class II, Type A. Diagrammatic illustration showing approximate dynamic equation responsible for the wedging of an upper second molar out of its normal location, subsequent to the extraction of the adjacent third molar. (See text.)

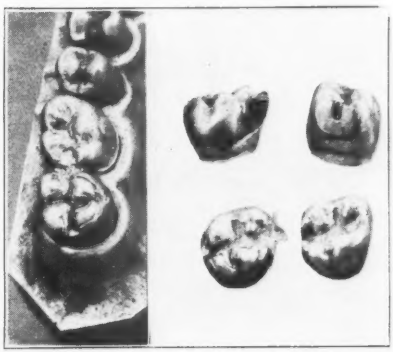


Fig. 14.—Dr. Burgess' contrivance. Left: In position. The interlocking of these inlays keeps the occlusal embrasure closed to food impaction and prevents the distal tooth from being wedged away from its neighbor. In addition, by virtue of this same semirigid binding arrangement, the tighter of two teeth has a stabilizing influence on the looser one. In addition, this valuable device is used to prevent or halt the elongation of a tooth deprived of its occlusal antagonist. For this specific purpose, it is necessary to place the female attachment on the tooth so affected and to solder the male part to its neighbor. Right, above: Proximal view of the male and female attachments. For improved stability, it is frequently advisable to attach the male part to a McBoyle attachment, as shown in this illustration. Right, below: Occlusal view of the individual components.

the wedging force may be further enhanced by increased steepness of the inclines. The tremendous wedging power thus produced may be effective to a greater or less degree even in the face of the remaining essential anatomic safeguards.

Correction: Figure 4 explains a simple method used successfully in a number of instances in the elimination of this type.

Type B: Remaining Obliquely Worn Cusp of an Upper Tooth Overhanging Distally Its Opponent (Fig. 5). — This usually occurs where, as a result of advanced horizontal occlusal wear, the teeth are either partially extruded out of their sockets (if the wear is localized to individual teeth only) or the maxillae approximate each other (if the wear is generalized). Because the distal cusp of the distal tooth of the upper arch is generally in only partial contact with its opponent, it becomes only partly worn, usually into an oblique facet which protrudes beyond the occlusal plane immediately behind the opposing tooth.

A morsel of tenacious food between the oblique distal facet on the lower tooth and the mesial facet of the overhanging distal cusp of the upper may force the latter distally, the interdental space between it and its mesially adjacent tooth being opened thereby. This invites food impaction. In such a condition, with but few exceptions, the space cannot be opened without food as a medium because the mandible is not brought back sufficiently to push the upper tooth distally. This type concerns especially the upper third molar and less frequently the

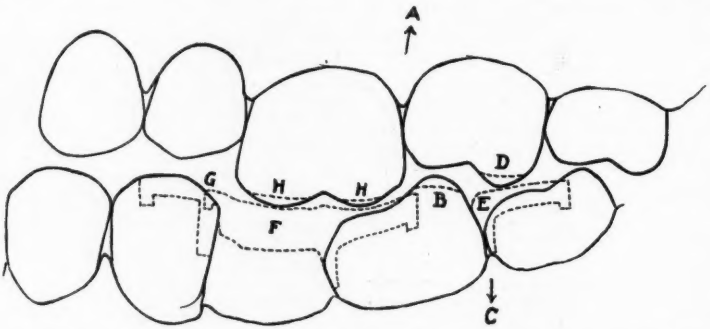


Fig. 15.—Class II, Type C. For the relief of impaction between the lower second and third molars (*c*), the following steps may be effective. 1. Reduce the distal cusps (at dotted line *B*) of the lower second molar and sometimes that (*D*) of the upper, if it acts as a plunger. 2. Establish mesial support for the second molar by attaching to it a pontic (*F*) with a rest (*C*) on the second bicuspid. (If the pulp in the upper first molar is vital, grind its cusps down (*H-H*) as far as possible without producing sensitiveness. If the tooth is devitalized, it is preferable to cut it down and rebuild to the occlusal plane, prior to making the lower restoration.) 3. The mesial cusps of the lower third molar may be raised by means of an inlay restoration (*E*), the impaction funnel being thereby eliminated. In the upper jaw, the food impaction produced by the elongation of the first molar and oblique tilting of the second and third (*A*) may likewise be eliminated by reducing the plunger cusps and building in the funnels. In this condition, when the distal cusp of the upper third molar drops down behind its opponent, the mere reduction of that cusp with a stone may solve the problem of impaction between the upper second and third molars.

second. It may occasionally also affect some of the teeth anterior to these, if distal contiguity is lacking.

Correction: This condition is remedied very simply by grinding off the overhanging cusp (Fig. 5, *C*).

Type C: Obliquely Worn Lower Tooth Overlapping Its Opponent Distally (Figs. 6, 7 and 8).—This mechanism is very similar to Type B; but here, the distally overhanging cusp is on a lower tooth, generally the third molar when its upper counterpart is missing. The mesial cusps are worn down by the distal cusps of the upper second molar. It differs from Type B also, in that a distal forcing of the tooth and the resultant opening of the interdental space may be produced without the presence of food as a dynamic intermediary. This occurs as the mandible moves forward during function, and the protruding unworn distal part of the lower third molar is struck and pushed backward by the upper second molar, which produces occlusal trauma, and also impaction of whatever food may be present.

Correction: Reduction is made of the protruding part of the lower molar (Fig. 7.) For the prevention of further extrusion out of the socket, the Burgess contrivance is effective (Fig. 14). Another malfactor in food impaction produced by occlusal wear but which may not be termed a type as it is only an accessory, though very potential, is the concavity on the summit of a plunger cusp (Figs. 9 and 11). When opposite a normally constituted antifood impaction mechanism, this is of no serious consequence, but if the latter is defective, the mechanically inclusive character of the concave area helps to guide, concentrate and force the

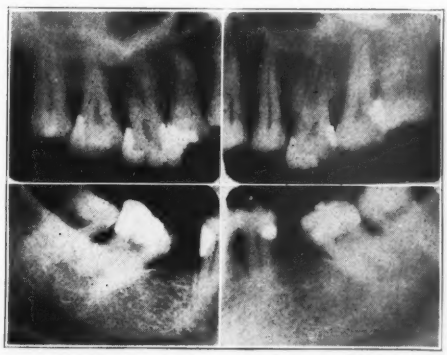


Fig. 16.—Both sides of a case such as is presented in Figure 15, showing the tilting mesially of all upper and lower second and third molars and the elongation of the upper first molars. The proximal fillings resulted from food impaction due to enlarged occlusal funnels and close interdigitation of the plunger cusps. The distal fillings on the lower bicuspids were caused by an unhygienic condition underneath the cast clasps of a removable bridge. The patient presented no proximal caries anywhere else. At all points where the food impaction was occasioned by the mesial tilting of the teeth, caries had taken hold on the mesial side of the interproximal spaces only.

food into the opposing interproximal space.

Correction: The concave cuspal area is ground until there is a convexity, and, if necessary, a further reduction of the cusp is made.

CLASS II: LOSS OF PROXIMAL SUPPORT

Although the sudden loss of contiguous support, through extraction, will show no immediate effect in some mouths, especially in older individuals with advanced horizontal wear and a normal supplement of alveolar process (Fig. 2), in a large majority of cases its pernicious influence is evident quite soon. The kaleidoscopic changes resulting from this loss of contiguity bring with them not only perverted function but also traumatizing agencies, among which traumatic occlusion and food impaction are outstanding.

Loss of contiguity may result in food impaction through the establishment of permanently open interproximal spaces due to drifting, or through the temporary opening up of spaces by wedging incidental to mastication. In neither instance can the marginal groove and ridge serve effectively in the prevention of food impaction.

Type A: Loss of Distal Support Through the Removal of a Distally Adjacent Tooth.—This may result from the extraction of any tooth distad from the central incisors but particularly one in the posterior region. This type is very frequently inaugurated through the extraction of the first or third molar. Thanks to recent vigorous propaganda in preventive dentistry, more first molars are saved now than heretofore, but the third molar is still the scorned stepchild of the dental arch. While the extraction

Fig. 17.—Mandible of Australian aboriginal. In this specimen, there was no indication of alveoloclasia in any other part than the septum between the second bicuspid and the first molar. The destruction of the crest here as well as the formation of the proximal cavity in the distal side of the bicuspid was evidently caused by the impaction of food through the mesioclusal cavity in the molar. According to the rest of the denture of this skull, caries existed only where the occlusal spaces, formed by the chipping away of the proximal edges of enamel weakened by extreme occlusal wear, invited food impaction. It seems that food impaction was a prerequisite for any possible beginning of caries. (Film made at the American Museum of Natural History.)

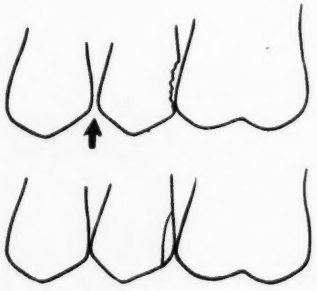


Fig. 18.—Above: Occlusal opening to the interproximal space between the bicuspids, caused by drifting due to the destruction of the distal contact point of the second bicuspid. Below: Opening closed prior to restoring the contour of the contact point, to prevent further impaction.

of this tooth on account of malposition, impaction, infection, etc., is most often highly justifiable, the predominating indifference toward maintaining its welfare when in normal position should be discouraged. This tooth, when normally situated, is a greater asset to our dental economy than is generally recognized. One of its essential functions is to help maintain the dental arch. Many of us have seen instances in which the extraction of from one to four third molars in the same mouth was followed almost immediately by the establishment of food impaction mesially to every second molar next to which the extraction was done (Fig. 12).

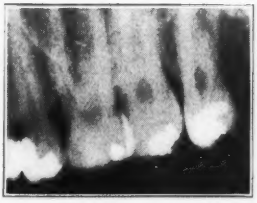


Fig. 19.—Elongation of the upper third molar due to the partial eruption of its opponent in a patient, aged 19. Because mastication was avoided on this side, there is no food impaction. For that reason and because the tooth had erupted only recently, there was no interproximal caries. The tendency of the alveolar process to elongate with the tooth is evident.

For the purpose of illustration, in impaction between the upper first and second molars caused by the extraction of the third, what morphologic elements and dynamic forces are brought into play? For various reasons, the second bicuspid and the first and second molars do the most work in the comminution of food. By virtue of their location in relation to the masticatory musculature, the intensity of occlusal pressure in this area is very great. For simplicity in calculation, we will assume that the mesially and distally inclined occlusal planes of the opposing molars are approximately the same size (Fig. 13). The upper second molar has two mesially inclined planes against which pressure through the medium of food is exerted distally by the two distal planes of its opponent. To neutralize this pressure, we have the mesial plane of the distal cusp of the lower second molar and that of the mesial cusp of the lower third molar

Fig. 20.—Elongation of both upper third molars because of the absence of their opponents. This brought on food impaction in the same place on both sides of the mouth. While one may be inclined to extract both these teeth at once as the simplest remedy for permanent relief, the argument against it presented by the patient in the case of Figure 21 merits consideration.

exerting pressure mesially against the two distal planes of the upper second molar. But with distal contiguity eliminated through the loss of the upper third molar, we are minus that much resistance to distally directed pressure exerted by the

interdental wedging action of the mesial (usually the mesiobuccal) cusps of the lower second molar. We now have the mechanical equation which will permit food to be impacted between the upper first and second molars. The same mechanical equation is, I believe, greatly, if not entirely, responsible also for the nonpathologic mesiodistal drifting of teeth. The degree of distal mobility and the extent of food impaction may be increased through (1) the reduction of mesial pressure by a concomitant absence of the lower third molar and by (2) minimized resistance occasioned by a decrease of the distal alveolar support. The latter occurs frequently and may be due either to pathologic destruction of the alveolar septum or to pressure absorption caused by an abnormal manner of eruption of the third molar. If the third molar is missing congenitally, the normal complement of distal bony support furnishes the approximate normal balance, and food impaction does not necessarily ensue.

Correction: One of the best means of preventing food impaction in this type is an interlocking device, introduced by James Kendall Burgess, of New York, which serves several other purposes with similar efficiency (Fig. 14).

Fig. 21.—Denture in which extraction of the upper left third molar on account of food impaction was considered. The patient pleaded that it be retained, citing as her reason the strategic value of the third molar on the right side, which gave her anchorage for a bridge, thus obviating a partial denture with a palatal extension to the other side of the arch. This is one of the numerous reasons which prompt the conservation of the third molars.

Fig. 22.—Class III, Type A. Extreme elongation caused by the extraction of the opposing tooth. Such teeth, if permitted to, may grow sufficiently near to the gingival ridge to injure it. The palatal cusp is lowered additionally by the buccal tilting of the tooth.

Type B: Loss of Mesial Support Due to Extraction.—In this type mechanism, the unsupported tooth is forced mesially. The mechanical principles are similar to those in Type A, but there are four additional factors in the morphology of the masticatory apparatus which increase the

dynamic intensity with which the tooth is forced away from its neighbor, thus accentuating the tendency to food impaction. These factors are (1) the anteroposterior V-shaped relationship between the occlusal planes of the maxillary and mandibular arches, which, during mastication, tends, with food as a medium, to tilt the crowns mesially as the jaws approximate each other; (2) the decided (normal) mesial incline of the teeth, and (3) the greater surface area and more nearly horizontal position of the distal than of the mesial planes.

In a complete dental arch, these factors are evidently responsible also for the permanent maintenance of its contiguity in spite of the marked proximal wear through hard and long use.

Correction: The missing tooth is replaced with a properly supported pontic.

Type C: Oblique Drifting Due to Nonreplacement of a Missing Tooth.—This is similar to Type B except for the fact that the crowns of the teeth, posterior to the space caused by a tooth extraction, have drifted mesially, with the apices of their roots remaining in their original location. In addition to the lost mesial support, the oblique position thus obtained intensifies the impaction of food through the resultant overemphasized occlusal embrasure, which acts as a funnel into which food is frequently packed by an opposing plunger cusp especially elongated through a similar drifting of the upper teeth. The marginal grooves and ridges practically lose their functional value. The classic picture of this type is that of the kaleidoscopic changes produced by the extraction of the lower first molar (Figs. 15 and 16).

Correction: The distal cusps of the lower second molar are reduced as are sometimes those of the upper, if they act as plungers. Mesial support is established for the second molar by attachment to a pontic. The mesial cusps of the lower third molar may be raised by means of an inlay restoration. (Fig. 15.)

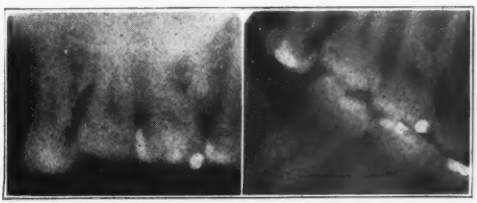


Fig. 23.—Case shown in Figure 22; the food impaction mechanism. Proximal caries, which usually attacks the elongated tooth first, is present.

Type D: Permanent Occlusal Openings to Interdental Spaces.—These are either congenital or acquired. The latter may result from:

1. Drifting subsequent to the extraction of neighboring teeth.

2. Forcing of teeth out of their normal position in the arch by various habits.

3. Periodontal disease: (*a*) drifting that is due to pericemental and alveolar destruction; (*b*) pressure produced by the expansive action of subgingival chronic inflammatory tissue; (*c*) the presence of epulides as well as interproximal proliferative gingivitis of pregnancy, producing, in addition, marked

traumatic occlusion. In this case, contiguity is usually restored automatically with the removal or disappearance of the pathologic tissue.

4. Proximal caries. The breaking through of a weak occlusal wall of a proximal cavity may inaugurate food impaction directly through the confining shape of the cavity which directs the food cervically under the force of occlusal pressure. Needless to say, this is capable of destroying the septal structures even in mouths of persons generally not susceptible to periodontoclasia (Fig. 17).

Correction: A properly contoured restoration assures correction.

5. Drifting of adjacent teeth together through the breaking down of proximal contact points by caries, a permanent occlusal opening to a neighboring interdental space being left thereby (Fig. 18). This may have been the only condition required to turn a potential food impaction mechanism into an actual one.

Correction: Obviously, it is important to bring such a tooth back into the original contact with its neighbor prior to filling the cavity.

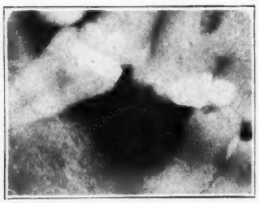


Fig. 24.—Overlapping of the upper third molar, the result of the drifting forward of its lower opponent because of the absence of the first and second molars. The upper teeth were wedged apart by the distal cusp of the lower through close interdigitation. Food impaction was practically eliminated through the reduction of the distal cusp of the lower, and the palatal cusp of the upper third molar.

CLASS III: EXTRUSION OF A TOOTH BEYOND THE OCCLUSAL PLANE

Extrusion of a tooth beyond the occlusal plane is an abnormal anatomic arrangement which may bring about, in addition to food impaction, a severe degree of traumatic occlusion.

Type A: Extrusion of the Distal Tooth of the Arch.—While this type may be inaugurated by the extrusion occlusally of any posterior tooth which happens to be the distal unit of the arch, it is best illustrated by the upper third molar, which is probably the most frequent offender. Different factors may cause the elongation of this tooth beyond the occlusal plane of the lower arch, the outstanding ones being: (*a*) congenital absence, delayed eruption or partial or complete impaction of the opposing tooth (Figs. 19-22); (*b*) the tilting forward of both the second and third lower molars on account of the extraction of the first (Fig. 24). With the extension of the tooth beyond the occlusal plane of its adjacent neighbor, an emphasized occlusal embrasure is formed into which

Fig. 25.—Elimination of food impaction by grinding the cusps along the dotted line in such cases as are shown in Figures 22 and 24. Further elongation is prevented through use of the Burgess device; but when the elongation is too great, as in Figure 22, extraction is usually preferable.

the distal cusp of the lower second molar acts as an effective plunger (Fig. 25). Again, the part of the morsel of food which is caught between the distal side of the lower second molar and the mesial of the overhanging upper third, acts as a very powerful wedging medium which pushes the latter tooth distally, thus opening the interproximal space for entry of food. The wedging process is frequently augmented if the periodontium does not join the tooth in its downward extension. The clinical crown becomes longer and the clinical root shorter, a longer power arm and a shorter weight arm resulting. The ease with which such a

Fig. 26.—Drifting mesially of the lower right second and third molar, on account of the absence of the first molar. The upper third molar elongated through the rapid wear on the concave surface of the distal cusps of the lower second. This resulted in development of a very powerful wedging outfit causing, through food impaction, extensive proximal caries and septal destruction between the upper second and third molars. This is a good example of some of the far-reaching ill-effects of nonreplacement of a missing lower first molar.

tooth could be wedged apart from its neighbor is apparent, also the pernicious traumatizing effect on its periodontium.

Correction: In the early stages of elongation, the cusps are reground as in Figure 25, and to prevent further elongation, secured by means of the Burgess contrivance (Fig. 14). If the condition is advanced, as in Figure 22, extraction is usually indicated.

When conditions are reversed, namely a lower third molar is permitted to elongate distally from the upper second molar (Fig. 27), an additional mechanical force is sometimes encountered as in Class I, Type C. During the forward migration of the mandible, the lower third molar is also traumatized by its direct thrust against the distal surface of the upper second molar.

The peg shape and shortness of the root and the distal curve characteristic of both the upper and lower third molars all tend to hasten further extrusion of this tooth, by a sort of prying process, every time it is forced distally by food impaction, or in the case of the lower tooth, by "rear end" traumatic occlusion, as it were.

Correction: The cusps involved are reground, and for permanent retention, the Burgess contrivance is used.

Type B: Extrusion of a Tooth Retaining Contiguity on Both Sides.—The general scheme of the normal mesiodistal occlusal relationship whereby most teeth occlude with two others has numerous advantages. Not the least of these is the partial functional capacity retained by a tooth after the extraction of one of its occlusal opponents. This advantage is often only short lived because of the abnormal changes which are initiated in both arches soon after the extraction. For illustration, I shall once more refer to the result of nonreplacement of a lower first molar. As previously stated, the lower second molar soon tilts mesially, which causes a tipping of its mesial cusps, the only ones now opposing the upper first molar. As a result, the latter tooth

is extruded, the extrusion closely following the opposing cusps considerably beyond the occlusal plane of the arch. One of the abnormal byproducts of such extrusion is the formation of a gross funnel which points to the interproximal space between the upper first and second molars. The protruding part of the distal surface of the first molar forms the mesial segment of the funnel, while the effective by the close interdigitation of an opposing cusps which acts as a plunger. Food impaction ensues even though contiguity is unbroken (Figs. 15 and 16).

Correction: Partial reduction is made of the plunger cusp and the distal cusp of the elongated tooth, the latter for the purpose of rendering the funnel less deep (Fig. 15).

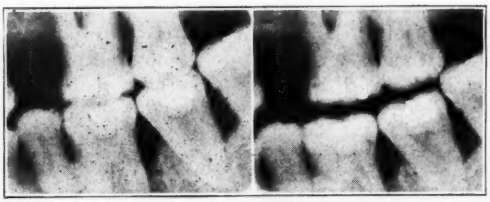


Fig. 27.—Class III, Type A, Subtype C. Left: Centric occlusion; showing the distal overlap of the lower third molar, which is alone sufficient to effect food impaction. Right: Eccentric occlusion; illustrating the ease with which the lower molar may be traumatized and forced distally by the upper molar.

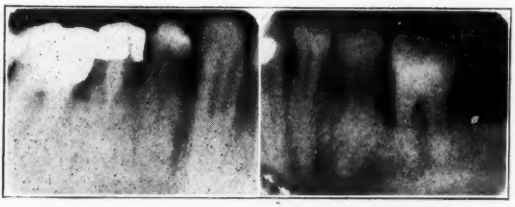


Fig. 28.—Class IV, Type A. Left: Lower first bicuspid in torsion. The food impaction mechanism was enhanced by the break in contiguity mesially to that tooth. Caries, due to food impaction, is present. Right: Lower second bicuspid in torsion. Lack of proximal support distally from the molar facilitated food impaction. Proximal caries and advanced destruction of the septum at the point of impaction may be noted.

mesial inclines of the mesial cusps of the second molar form the distal segment. The marginal ridges and grooves of the first and second molars have obviously lost their protective value against food impaction. This mechanism for food impaction is frequently made more

CLASS IV: CONGENITAL MORPHOLOGIC ABNORMALITIES

Earlier in the paper, reference was made to the importance of some of the anatomic elements in the prevention of food impaction. Their deviation from normal, acquired or congenital suggests

the possibility of food impaction. The following types result from congenital deviations:

Type A: Position of a Tooth in Torsion.—As stated before, the nearer the point of contact to the occlusal plane, the smaller the occlusal embrasure, and, therefore, the less likely the occurrence of food impaction. A consideration of the topographic distribution of convexity discloses that, with the tooth standing in torsion, the nearer the approach to the complete quarter turn, the further removed is the contact point from the occlusal plane. Outstanding among the teeth most frequently found in torsion is the lower second bicuspid. The height of the convexity of this tooth, though very

Fig. 29.—Upper first bicuspid in rotation. Food impaction is further facilitated by the loss of proximal support on the distal side of the second bicuspid. Caries is present in the first bicuspid. In all cases of this type so far noted by the author, caries started first, and probably only, at the contact point of the tooth in torsion, while the adjacent tooth was either affected secondarily or not at all. (Compare Figure 28.)

close to its occlusal plane proximally curves down on the buccal side to about the junction between the middle and cervical thirds of the crown. While this low level on the buccal surface has a specific protective function when the tooth is normally placed, it has a marked injurious influence on the interproximal tissue when the tooth is rotated one quarter turn. A funnel is formed that is not only deep, tapering and unprotected by the marginal groove and ridge, but has also a very wide open base into which large sized tenacious pieces of food may be tightly compressed and wedged (Figs. 28 and 29). The dynamic force is frequently intensified by the confining influence of the overhanging cusps of the opposite bicuspid, following closely the curved outline of the perverted embrasure.

Correction: While food impaction may in certain instances be greatly reduced or entirely eliminated by merely shortening the plunger cusp and the cusp in torsion, it is advisable to restore contiguity on the distal side if it is lacking.

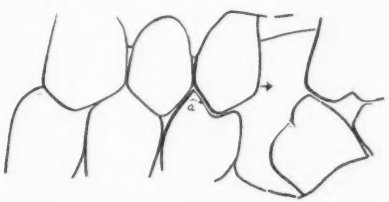


Fig. 30.—Lower second bicuspid in torsion producing food impaction between the upper first and second bicuspids. The food impaction mechanism was formed by the very close interdigitation of the steeply inclined planes of the deep wedge-shaped funnel and the plunger cusp. (The anatomic buccolingual inclines of this cusp are steeper than the mesiodistal.) Because the planes involved were worn into facets and the upper second bicuspid was minus its distal support, the impaction of food was made more effective. The mere preliminary step of reducing the plunger cusps at *a* was sufficient to stop the impaction completely.

Sometimes, placing an inlay or porcelain jacket crown in normal position accomplishes the desired result. While rotation by orthodontic means may yield satisfaction in the case of the upper bicus-

pids, the lowers are too round and tend to return to the original malposition, unless interlocked with an adjacent tooth.

Type B. Emphasized Embrasures Between Thick-Necked Teeth. — While Type A is the result of a normally shaped individual tooth standing in torsion, a similar type may be presented by thick-necked teeth in normal position. Sets of such teeth, with normal alveolar support, may serve through a lifetime without any serious interproximal impaction, especially if the plunger cusps run short of following the food up sufficiently into the funnels. When steeply inclined mesial and distal planes are worn on closely interdigitating cusps, food impaction may result (Fig. 12).

Correction: Sometimes, this is easily remedied by shortening the cusps and rounding the facets. If this is of no avail, the teeth may be remodeled with inlays, the contacts being brought close to the occlusal plane.

Type C: Buccolingual Tilting. — When a tooth is inclined buccally or lingually to the arch, the resulting perverted large occlusal embrasure is unprotected by the marginal ridges and grooves. As a matter of fact, this perverted occlusal embrasure may really be formed by the anatomic buccal or lingual embrasure on the side inversely opposite to the direction of the inclination. In certain instances, the plunger cusp of the opposing tooth, which is frequently tilted somewhat in the other direction, may follow the food up into the embrasure very closely, directing it toward, and finally

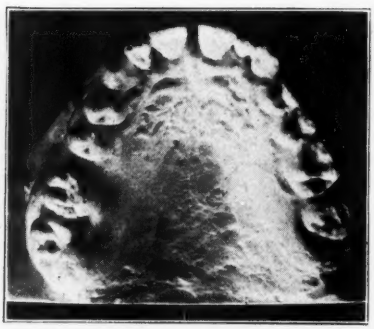


Fig. 31.—Class IV, Type C. The tilting buccally of the upper right third molar made it possible for the opposing plunger cusp to force food through the palatal interproximal embrasure into the proximal space, causing destruction of the gingiva, as indicated in the illustration. The constant trauma produced made this a point of low resistance and accordingly a focus for reinfection by Vincent's organisms.

Fig. 32.—Class IV, Type D. Food impaction between the upper left bicuspids ceased only after reducing the buccal cusp of the second bicuspid, which, through its inharmonious interlocking of the opposing buccal and lingual cusps, was forced palatally by the lateral swing of the mandible. This opened the proximal space between the two upper bicuspids to food impaction and a suppurative periodontoclasia on the first bicuspid stubbornly resisted treatment until after elimination of the food impaction.

forcing it into, the interproximal space. The outstanding example of this type is found in the buccally inclined upper third molar (Fig. 31). In this instance, the plunger cusp frequently approaches the interproximal space and tissues quite intimately. As a result, the food is forced directly into the interproximal space without necessarily wedging the teeth apart, but inflicting severe injury on the soft tissues.

Correction: Reduction of the plunger cusp is frequently effective, but extraction of the upper third molar is often indicated, especially because the buccal cusps sometimes injure the cheek, and interfere with the maintenance of hygiene on the buccal aspect.

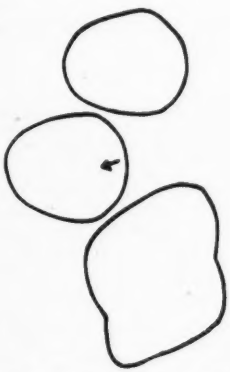


Fig. 33.—Diagrammatic drawing showing the opening of the interproximal spaces when a tooth standing palatally to the arch is forced away from its neighbors by the action of an opposing tooth during mastication.

Type D: Lingual or Buccal Position of a Tooth.—This is similar to Type C, but the buccolingual inclination of the tooth is not so great. When a tooth stands buccally or lingually to the arch, crowded out by the approximation of its adjacent neighbors to each other (Fig. 32), food impaction is frequently invited by the following mechanism: The abnormal position of the tooth outside the arch invites a form of traumatic leverage caused by its inharmonious buccolingual occlusal relationship. This often results in the tooth's being forced still farther out of the arch and thus away from contact with its neighbors (Fig. 33). Hence, spaces may be opened for food impaction without the aid of a typical wedging mechanism. When a perceptible pericementitis is produced by coexisting occlusal trauma, the resultant thickening of the membrane extends the radius of buccolingual movement of the tooth, thus producing food impaction more readily.

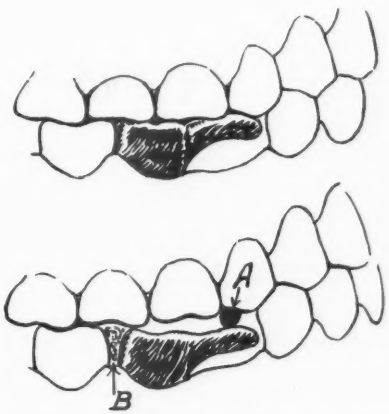


Fig. 34.—Class V, Type D. Above: Case in which, although food impaction is quite annoying to the patient, the contact may be so close during rest that dental floss is severed in an attempt to pass it through. At this time also, the pontic may be in perfect occlusal relation with its opponent. Below: 2. Case shown above, during mastication. As the pontic is forced downward by tenacious food (*A*), it acts as a lever and opens the proximal space to food impaction at *B*. (The action in this diagram is accentuated for better visualization.)

Correction: Orthodontia is employed where permissible; otherwise, a reduction is made of the interlocking cusps.

CLASS V: IMPROPERLY CONSTRUCTED RESTORATIONS

In an analysis of the causative factors of food impaction, improperly constructed restorations are found to play no small part. Some of these faults in reconstruction are no doubt well known to most of the profession. The following are some of the outstanding types under this classification

Type A: Omission of Contact Points.—In rounding out proximal contours, various well-known precautions in operative procedure must be taken. If not, an otherwise good restoration may fail through lack of contact points. The space thus produced, however small, may permanently permit the impaction of food. In such cases, one must not be tempted to take comfort in the fact that teeth, for reasons described earlier in the paper, tend to move forward and thus reestablish contiguity. Food impaction may operate against this.

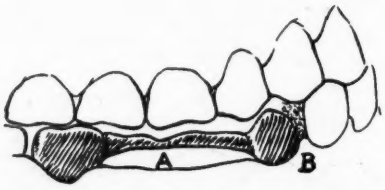


Fig. 35.—Bending at the weak point near the center (*A*) of a self-cleansing bridge causing its shortening, and the consequent food impaction at *B*. This was made possible either by faulty heat treatment or the use of metal of poor quality.

Correction: It is obvious that refilling with establishment of contacts is frequently the only procedure.

Type B: Improper Location of Restored Contact Points.—The mechanical and biologic disadvantages of the improper location of contact points have been described in another part of this paper.

Type C: Improper Occlusal Contour.—This results from:

1. Omission of the marginal groove and ridge.

2. The concave, flat or too steeply inclined construction of mesioclusal and distoclusal planes in the mesiodistal direction. This is likely to cause a wedging process, leading to food impaction.

3. The building out of the cusp on a tooth which is out of buccolingual alinement in a manner that would cause excessive buccolingual leverage during mastication. This may result in the temporary opening of the interproximal space during mastication.

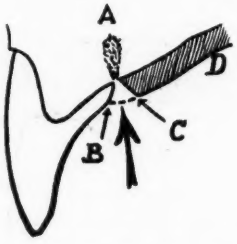


Fig. 36.—Class V, Type E. *A*, food impacted into the subgingival crevice through the funnel *B-C* caused by the bevel of the plate at *C*.

Type D: Improperly Constructed Cantilever Restorations.—The occlusal pressure of tenacious food against the unattached end of the pontic causes a bending of the pier tooth away from its neighbor; which produces an occlusal opening to the interdental space and consequent impaction (Fig. 34). In some mouths, especially those susceptible to

periodontoclasia, the pier tooth very soon finds tself in a permanently inclined position. In such instances, the diagnosis and etiology of food impaction is usually very simple: the dropping of the pontic below the occlusal plane, the inclination of the tooth and the presence of the open interproximal space constitute the tell-tale combination.

A condition similar to the foregoing may sometimes be noted where a "self-cleansing" bridge is employed. Instead of a cantilever construction, two "cusps" replacing, for instance, a lower second bicuspid and a first molar, are attached to a shell crown on each side (Fig. 35). If, through lack of foresight, the thinnest part of the bridge is about half way between the piers, it may soon yield sufficiently to the force of mastication to bend progressively downward. The result is a proportionate shortening of the length of the bridge, and therefore a pulling away of the pier teeth out of contact with their neighbors. Food impaction follows.

Type E: Scalloped Cervical Bevels on Rubber Dentures.—The cervical semilunar bevels, which some dentists seem to delight in making on partial rubber dentures, cause a pernicious type of food impaction which we still meet with occasionally and which differs from most others in that it is not located interproximally. As these are situated opposite the teeth, especially the upper anterior, they frequently form funnels through which food is forced and directed right into the subgingival crevices. This action either inaugurates the formation of deep pockets or accelerates the progress of those already existing. The necessity for the immediate elimination of this menace is self-evident.

It may not be amiss to state that, although the foregoing formulas for food impaction mechanisms are in general easily analyzed and classified, there are instances in which the complete etiologic picture must be arrived at, mainly through free play of the operator's imagination plus, at times, a set of properly articulated casts. This contribution to dental science, although comparatively lengthy, is incomplete, and I hope that, in view of the importance of this subject, others whose interest it may arouse will add to and improve on its contents.

SUMMARY

1. Close observation reveals a morphologic arrangement which serves to prevent food impaction, the principal constituent factors of which are (*a*) contiguity of the arch, (*b*) proper location of the points of contact and (*c*) the presence of the marginal ridge and groove.

2. Since food impaction may be inaugurated through the absence of any of these, a careful checking up in this respect during the course of operative or restorative procedure is therefore an important precautionary measure in preventive dentistry.

3. In an analysis of food impaction mechanisms, we must regard the occlusal embrasures, major and minor, as potential wedge-shaped funnels through which food tends to be directed and forced into the interproximal spaces, and the opposing interdigitating cusp as a potential plunger which tends simultaneously to wedge the teeth apart (with food as an intermediary) and push the food through the occlusal opening thus produced.

4. In such mechanisms, the steeper the component sides of both the funnel and the opposing wedge, and the less convex their contour, the greater the wedging and food impaction action. In other words, the potency of the food impaction

mechanism is in direct ratio to the degree of proximal occlusal interdigitation.

5. Thus, it is obvious that the correction of these abnormalities to the greatest permissible degree should constitute an important item in remedial procedure.

6. The forcing apart of adjacent teeth may be accomplished by opposing mesiodistally oblique planes more remote than those forming the occlusal embrasures and plunger cusps.

7. Food impaction mechanisms may be classified according to their etiology, as follows: Class I: Occlusal wear; Class II: Loss of proximal support; Class III: Extrusion of a tooth beyond the occlusal plane; Class IV: Congenital morphologic abnormalities; Class V: Improperly constructed restorations. These are subdivided into types that appear constantly, as described in the text, besides which there are numerous subtle modifications.

8. While some food impaction mechanisms may be expeditiously reduced or completely removed by grinding with a stone, the operator must, as in the correction of traumatic occlusion, be very cautious, before and during the procedure, not to initiate new complications.

9. It is logical to believe that the dynamic equation underlying the mechanical action between oblique opposing mesiodistal planes which produce food impaction is, in the main, likewise responsible for the nonpathologic mesiodistal drifting of teeth.

10. The importance of retaining the normally erupted third molar cannot be overstressed. Its loss, through the various ultimate effects of food impaction or other causes, must be guarded against with the utmost care.

11. In the course of my study of food impaction, the following interesting facts have been observed: (*a*) Where food impaction is the principal factor in wedging a tooth away from its neighbor, the septal structures between the two may remain comparatively intact on the side of the tooth moved, while, on the other side, destruction takes place, with deep pocket formation (Figs. 8, 12 and 23). This is probably due in part to pressure exerted on the food in the opposite direction, by the recoil of the moved tooth on its relief from the occlusal wedging force. (*b*) When food impaction results from the elongation of a tooth, proximal caries seems to occur first, and probably only, on the side of the elongated tooth. (*c*) When food impaction results from the oblique tilting of teeth, proximal caries seems to start first, and probably only, on that side of the interproximal space toward which the teeth are inclined. Here, as in the previous instance, the caries usually has its inception in the denuded cervical cementum. (*d*) When the torsion position of a tooth causes food impaction, caries seems to start first, and probably only, on the rotated tooth, usually at the contact point. (*e*) An upper posterior tooth deprived of occlusal opposition always tends to tilt buccally. The third molar illustrates this most frequently.

12. A consideration of the great number of abnormal and pathologic conditions resulting from food impaction (no less than twenty having been enumerated, from clinical experience), as well as their frequent incidence, indicates the necessity of a closer study of its prevention, detection and correction, which, up to date, has evidently been grossly neglected in dental literature.

FURTHER EVIDENCE THAT ROOT CANALS CAN BE FILLED TO THE DENTINOCEMENTAL JUNCTION

By CARL J. GROVE, D.D.S., St. Paul, Minn.

IN the June issue of THE JOURNAL, Balint Orban, of Vienna, Austria, makes the assertion that, through his researches, he has proved two points of contention in the root canal controversy: that a definite dentinocemental junction does not exist, and that this point cannot be used as an objective in filling root canals.

Because of the perils involved in the possible acceptance of Dr. Orban's claims, I am prompted to make a brief reply to correct these fallacies, for the highest degree of success in root-canal surgery cannot be attained where the dentinocemental junction is ignored.

First, let me make clear just what the issues under discussion are. Dr. Orban contends that a definite dentinocemental junction does not exist at the apex, his views being clearly set forth in the following quotation from his discussion: "If it is possible for Dr. Grove to cite any authorities, I should like to have him give the names of those who do not question the existence of a definite junction of the dentin and cementum at the apex, because I should like to see the pictures from the specimens upon which these statements are based."

Figures 1-3 are photomicrographs selected from the numerous specimens which I have that offer positive proof of the existence of a definite junction of the dentin and cementum. Dr. Orban's assertion regarding this question is not supported by facts.

The other contention is that the dentinocemental junction cannot be used as an objective in root filling. He states in his criticism that this is impossible.

Now, let us analyze briefly the evidence offered as the basis for this opinion. Dr. Orban makes the following statement at the outset of his discussion: "During my stay in America, I frequently had the opportunity to discuss in connection with root-canal problems the question of the 'dentinocemental junction.' I have discussed this with many successful operators, men who were vitally interested in this problem. From them, I have obtained the practical operator's point of view concerning the possibility of removing pulps and filling root canals to the dentinocemental junction. The almost unanimous opinion was that this could seldom be accomplished through intent." There is no evidence offered in this assertion. Dr. Orban has merely presented the opinion of other persons for his assertion: there is nothing scientific or conclusive in these deductions. To base an opinion upon this information is not scientific; neither do the investigations referred to below offer any light on the question, where he states: "During the time that I was director of the research laboratory at the Chicago College of Dental Surgery, Dr. Coolidge, on my suggestion, thoroughly investigated this

Fig. 1.—Section made from an upper first bicuspid. The dentinocemental junction at apex *A-A* is clearly shown.

Fig. 2.—Buccal root of upper molar clearly showing the junction of the dentin and cementum at *A*.

question on the basis of the very extensive human material at our disposal there. He showed how utterly impossible it was to use the dentinocemental junction as a landmark in root-canal work." Since there were no attempts made to fill root canals in these experiments, the character of the investigations conducted could not prove that filling to the dentinocemental junction is impossible; therefore, it cannot be justly claimed that the question was "thoroughly investigated."

Fig. 3.—Upper central incisor. *A*, junction.

Fig. 4.—*A*, part of gold cone in apical portion of the canal, extending into the cementum. The other portion of the cone dropped out when the section was ground, which left a space. There is a heavy deposit of cementum at the apex.

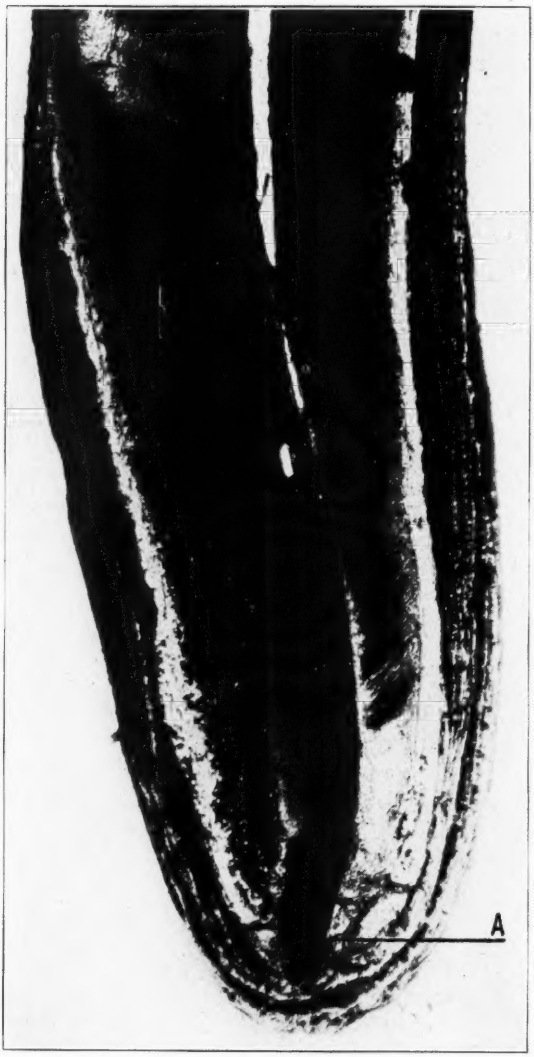


Fig. 5.—Section of tooth showing a curved canal. The upper portion of the gold cone has been ground away, owing to the curvature of the canal, which leaves a space, but the apical portion remains in position, extending to the junction of the dentin and cementum at *A*. A distinct junction of the cementum and dentin is apparent at the apex.

That roentgen-ray pictures disclose the fact that a large majority of canals are overfilled or underfilled does not prove that proper root-canal work is impossible. It merely discloses the character of the work examined. Neither can a true conception of the possibilities of any dental work be determined by an examination of operations in the mouths of the average patient. Such findings are misleading as to what is possible. It is well known that the majority of inlays do not have well-fitted margins, but this does not prove that inlays with good margins cannot be made. Neither does the fact that most canals are not filled to the dentinocemental junction prove that it cannot be done.

The purpose of having a definite objective is that overfilling or underfilling will not occur, and the chief reason for having the filling extend to the cementum is to obliterate the canal, in order to prevent serum from entering the canal, and also to prevent organism present in the tubules of the dentin from escaping into the periapical tissue. Extending the filling to the cementum is the only means of accomplishing this purpose. It is known that an open foramen can cause infection in this manner, and there can be no objection to sealing the canal at this point.

Dr. Orban states that filling to the dentinocemental junction can "seldom be accomplished through intent." The results of the following experiments refute his assertion. As it is not possible to obtain clinical material of this character, since patients will not permit extraction of their teeth for such a purpose, I have substituted laboratory material, as nearly comparable to the tissues of the mouth as possible. I selected teeth at random, imbedded them in plaster blocks and proceeded to prepare the canal and fill the roots according to the technic that I am using in the mouth, a technic that eliminates all guesswork. After the operation was completed, the teeth were removed from the blocks, sectioned and placed under the microscope for determining the results. More than 90 per cent were successfully filled to the cementum by this procedure, fully developed single-rooted teeth being used.

Figures 4-5, made from these specimens, clearly illustrate that the end of the gold cone extends into the cementum. I wish also to call attention to the presence of a definite dentinocemental junction. To retain the gold cone in position during the process of preparation, it was necessary to grind the sections; therefore, the specimens could not be made very thin without destroying the cone completely. This explains the thickness of the sections, but they serve very satisfactorily in showing that the filling extends to the cementum or the dentinocemental junction.

By the use of a technic in which measurements of the length of roots are obtained with the control of instruments and material, the same results can be obtained in the mouth.

MICRO-ORGANISMS AND CARIES*

By THEODORE B. BEUST, D.D.S., Louisville, Ky.

PAPERS on "Micro-Organisms and Caries" not infrequently follow the classic example by describing the formation of acids by micro-organisms and ending with the admonition to brush the teeth. A clean tooth, it is said, cannot decay. This sounds very simple, does it not? But let us go farther. Or, rather, before going farther, let us turn back a few pages of history, to be exact, to 1847, the days when germs were first brought into intelligent relation to the process known as dental decay. Ficinus is the investigator who is given credit for a good piece of work at that time, but it must be said that he believed his so-called germs to be worms. It was not until 1867 that Leber and Rottenstein, two physicians residing in Frankfort on the Main, propounded a caries theory which embraced all of the essentials of the one generally recognized today.[1]

On page 24 of their book, which is written in German, they state what, in the translation, would read: "Decayed enamel presents itself under the microscope as enamel that has been treated with acids, and differs from enamel so treated only in its brown coloring. On page 79, they write: "Although the secretions of the mouth are usually alkaline, an acid reaction often occurs on the surfaces of the teeth and gums. This acid may result from two conditions, either from an abnormal condition of the mouth secretions or from the fermentation of foodstuffs." On page 82, we read: "Acid reaction is made possible through the power of the saliva to turn amylum into sugar, which in the presence of a ferment forms acid." On page 86, there is added: "The nature of this acid, according to general opinion, is mainly lactic acid." After discussing the mouth micro-organisms, they state, on page 61: "From what has been said, the caries of the teeth depends on two main factors, the formation of acids and the growth of a parasitic plant, *Leptothrix buccalis.*" (Under *Leptothrix buccalis* was understood the most conspicuous thread forms found growing in the film on the teeth.) (Figs. 1-2.) I shall quote more from this excellent treatise on dental caries as we proceed.

But the chemicoparasitic theory still remained to be "put over." This was done, as you know, in the eighties by W. D. Miller, who, through his association with the University of Berlin, benefited from the phenomenal advances made in the laboratory of Robert Koch. The caries theory formulated by him at that time is the most generally recognized, on superficial inspection, the most plausible and, to the popular mind, the

*Read before the Peoria County Dental Society, Dec. 2, 1929.

*From the Research Laboratory of the School of Dentistry, University of Louisville.

*Work supported in part by a grant from the Research Commission of the American Dental Association.

1. Leber and Rottenstein: Untersuchungen über die Karies der Zahne, Berlin: Hirschfeld.

most easily adapted to the conditions as they appear to exist. Even so, hand in hand with this theory, there stalked what older investigators were wont to call the "vitalistic theory." This theory deals with the vitiation of the secretions or with the abnormal conditions occurring within the teeth as the cause of caries.

Leber and Rottenstein did not entirely exclude vitalistic influences from their deliberations. On page 48, they say: "Having shown that the changes occurring in caries must be the result of acids and micro-organismal growth, it is not at all impossible that vitalistic processes are associated in the phenomena." W. D. Miller, in his prize essay read before the Fourth International Congress,[2] in 1904, in dealing with the proven resistance to destruction by acids exhibited by transparent and secondary dentin, writes (page 273): "Whether the vitality of the tooth offers any obstruction to the advance of decay over and above that manifested by transparent and secondary dentin is a problem still to be solved at the expense of much patience and labor."

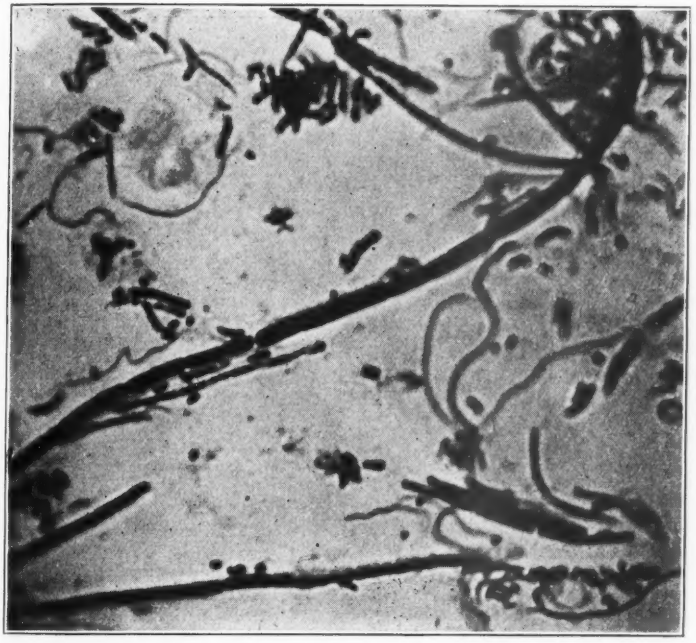


Fig. 1.—Typical threads (formerly included under the name "Leptothrix") from the film found growing on the enamel. In the background are spirochetes and other organisms.

We have thus far mentioned three factors which govern the inception and progress of decay: (1) micro-organisms, which produce ferments; (2) the formation of and attack by acids, and (3)

2. Miller, W. D.: Tr. IV Internat. Cong., Vol. 1, p. 237.

the resistance offered to the caries by vital forces resident within the tooth itself.

Miller, having shown experimentally that zones of transparent dentin forming under advancing decay exhibited resistance to decalcification,[3] accepted without question the occurrence of vital reactions within the substance of the dentin. In regard to enamel, he expresses himself very guardedly, saying, in effect, that enamel is "probably" passive.[4]

Today, the question of enamel vitality is being intensively studied. To comprehend the conditions existing in the enamel tissue, it will be necessary to learn the significance of certain markings known as tufts and lamellae, found in cross-sections of teeth. (Figs. 3-4.) Caush,[5] in 1904, showed that these figures were amenable to impregnation with dyes, but their continuity with the bodily lymph channels was, and even in the light of later experiments, still is, doubted. In 1912,[6] I injected these and other minute markings seen in unstained enamel by causing stains to permeate the dentinal tubules from the pulp cavity, also by causing stains to diffuse through the pulp itself into the enamel, via the dentinal tubules. That such results were possible seemed to justify the view that the enamel may

Fig. 2.—Leptothrix racemosa, found growing in dense mats on enamel surfaces.

3. Footnote 2, p. 44.
4. Footnote 2, p. 274.
5. Caush, Donald: Tr. IV Internat. Cong., Vol. 1, p. 170.
6. Beust, T. B.: Dent. Cosmos, 54:659 (June) 1912.

also receive lymph. In the summary of that report, I stated: "This vascularity of the enamel renders it possible, even probable, that the immunity to caries observed in some teeth lies in the tooth itself."

The results of these experiments should enable us to study our caries problems from this point of view, were it not for the incredulity expressed by many histologists who regard these structures as defects. Supposing that you were conducting an anatomic examination of any healthy organic tissue and found certain markings uniformly distributed throughout its mass, what would your impression be concerning these? (Figs. 3-4.) Now suppose that you examine a thousand specimens of such tissue and find the same structures in 100 per cent of the cases—what then would your impression be? Supposing that you have never been able to find a specimen of such tissue in which these structures were missing, how would that impress you? Supposing, furthermore, that all other investigators invariably find the same structures, what would you then conclude? Would it occur to you that you were here dealing with defects? Certainly not. That is the present-day situation. Even E. W. Fish,[7] who duplicated my experiments carried out on freshly extracted teeth by

Fig. 3.—Characteristic distribution of markings (tufts) as seen in cross-sections of teeth.

7. Fish, E. W.: Circulation of Lymph in Dentin and Enamel, J. A. D. A., 14: 804 (May) 1927.

injecting stains into the pulp of a live dog, speaks of defects. His *intra vitam* experiments corroborate my conclusions regarding circulation in the enamel. Indeed, Fish himself states[8] that the postmortem (diffusion) experiments are essentially identical to those carried on *intra vitam*.

The English histologist, J. Howard Mummery,[9] used my diffusion methods in 1922 and gave us a valuable contribution on enamel biology. A few years later[10] he described certain phenomena observable around areas of incipient caries of the enamel that deserve the most earnest attention on the part of investigators. Mummery showed that around each area of beginning caries, an area of resistance was evident. In only two out of twenty cases examined, no zones were visible. Mummery attributes their failure to appear to the rapidity of penetration of the caries in these cases. In demonstrating these areas, Mummery soaked the sections in borax-carmin for one week. In commenting on his results, he writes: "It is evidently not an area of decalcification, for the stain does not enter it but ends abruptly at its margin. Also in specimens in which the zone involves the striae of Retzius, these appear to be partially obliterated and have almost or

Fig. 4.—Extension of some of the tufts to the enamel periphery. Before the teeth are sectioned, stains may be caused to diffuse through the dentinal tubules into the tufts through which they may reach the enamel periphery.

8. Fish, E. W.: Lesions of Dentin and Their Significance in the Production of Dental Caries, J. A. D. A., to be published.

9. Mummery, J. H.: Brit. Dent. J., 43:607 (July 1) 1922.

10. Mummery, J. H.: Brit. Dent. J., 47: 473 (May 1) 1926.

quite disappeared in the clear area. These facts point to the probability of the translucent zone's being an area of denser calcification than the rest of the enamel."

Mummery, as we may perceive from the foregoing report, verifies my point of view, expressed in 1912, that immunity factors may be resident in the enamel. Mummery believes in the vitality of the enamel. The same view is in evidence in the writings of von Ebner, Caush, Percy R. Howe and Bödecker. Opposed to this opinion are the teachings of Tomes, J. Leon Williams and Hopewell-Smith.

Percy R. Howe,[11] basing his views on extensively conducted feeding experiments, believes that the enamel is permeable and, as a consequence, susceptible to nutritional influences. He states that the antiscorbutic vitamin is a factor in caries. He shows that ingestion of an excess of sugar and starches has caused no caries during experiments conducted over a period of nine months. A low protein, high lime, with basic ash, diet, as found in milk, vegetables and fruit, is conducive to the maintainance of an intimate union of the organic and inorganic constituents of the teeth. C. F. Bödecker,[12] a firm believer in the occurrence of metabolic changes in the enamel, has this year presented us with a theory of resistance to caries which, like Mummery's, confirms my utterances made in 1912,[4] but differs from what I had in mind in that he conceives of a neutralization of the acids formed by the microbial flora through the agency of the dental lymph

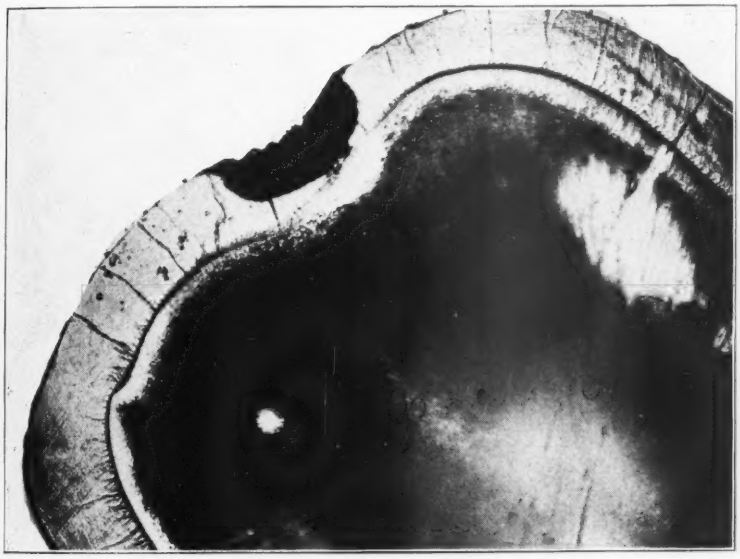


Fig. 5.—Cross-section of a tooth attacked by incipient enamel caries.

11. Howe, P. R.: Investigations of Dental Caries, J. A. D. A., 14:1864 (Oct.) 1927.

12. Bödecker, C. F.: Dent. Cosmos, 71:586 (June) 1929.

which circulates in the dentin and enamel.

After this superficial but rather lengthy preamble, in which only prevailing views were quoted and a few of nature's reactions illustrated, I shall mention, but not undertake to explain, some of the debatable points in our theories. These questions should interest all dentists. Our impotence in our crusade against the caries agencies is deplorable. Progressive professional men everywhere are broadening their conceptions, and learning to discriminate. I am aware that it requires the keenest sense of discernment to detect incongruities in widely accepted hypotheses, but, in 1911, it so happened that my audacity conquered over my store of caution and prompted me to publish statements which today might have remained unsaid. These were contained in two articles,[13] entitled "Discrepancies Between Immunity to Caries and the Theory of Caries." Three questions asked in these contributions, which have not yet been satisfactorily disposed of, follow:

1. Why is it, in view of the fact that all micro-organisms are acid producers, that the microbial film which flourishes on and adheres tenaciously to practically all enamel surfaces, does not always attack its substratum and produce caries? (Figs. 1-2.)

2. What is the difference between a film of micro-organisms and a plaque?[14]

3. Why is it that a plaque or colony of microbes, flourishing in an interdental

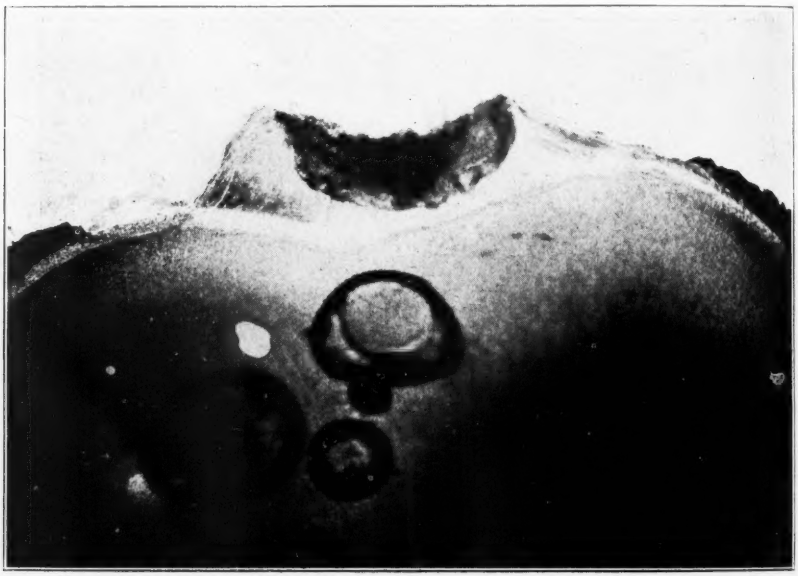


Fig. 6.—Section shown in Figure 5, after twenty hours' exposure to 1 per cent lactic acid.

13. Beust, T. B.: Dent. Cosmos, 53:724 (June), 1263 (Nov.) 1911.

14. Beust, T. B.: Dent. Brief, 18:853 (Dec.) 1913.

space, and simultaneously in contact with two teeth, frequently attacks only one of these? (Enamel is 97 per cent inorganic.)

4. Why do teeth so frequently fall a prey to pyorrhea, a disease characterized by an enormous increase in the mouth flora, without being decalcified?[15]

I am tempted to add to these questions today by asking:

1. Why look for specifically acid-producing strains (for instance, acidophilic bacteria) when the ordinary film can produce a sufficiency of acid to decalcify the tooth?

2. Why does caries most frequently start at the contact point (not, as erroneously believed, below it), where only a minimal amount of micro-organismal mass can congregate and where the carbohydrate supply must be deficient? (Here are found favorable conditions for putrefactive decomposition, not for acid production.)

With these thoughts in mind, I shall close by presenting another apparent incongruity learned from decalcification experiments conducted in my laboratory several years ago. It has long been known that whole teeth soaked in a carbohydrate broth inoculated with micro-organisms from saliva will gradually become decalcified. W. D. Miller noticed that areas which had become attacked by incipient enamel caries were relatively acid-resistant. He attributed this resistance to the protective influence of Nasmyth's membrane, which, before the loss of con-

Fig. 7.—Section shown in Figure 5, after twenty-four hours' exposure to the acid.

15. Beust, T. B.: Dent. Cosmos, 54:316 (March) 1912.

tinuity of the enamel surface, is found to have become thickened during the carious process. It would have been interesting to note Miller's reaction had he extended his studies to the complete calcification of ground sections containing caries spots. In such an experiment, the protective action of Nasmyth's membrane could no longer count as a factor influencing the result, as here the carious tissue is bathed from all sides by the acid. Such a method attests to the paradoxical fact that carious enamel itself is more resistent to lactic acid decomposition than sound enamel. The three illustrations appended will visualize the result. Figure 5 shows a ground section exhibiting a caries mark. Figure 6 shows the same section after a twenty-hour exposure to 1 per cent lactic acid. Only remnants of the enamel are remaining, but the carious enamel is still intact. Figure 7 shows the section after four more hours' exposure to the acid. The sound enamel has now been completely dissolved, the carious enamel remaining.

Future studies will probably determine the nature of the substance which has superseded the sound tissue, its significance and from whence it came. But one thing has already been shown; namely, that carious enamel is not simply enamel which has been decalcified by lactic acid and also that the caries produced in test tubes differs from the caries which occurs in the mouth.[16]

It is my sincere wish that this short discussion of the ailment to which operative dentistry owes its existence will help stimulate your interest in the problems of the day; will increase your estimation for even the tiniest speck of decay and, moreover, will remind many that a mouth contains more than simply teeth and restorations.

129 East Broadway.

16. Beust, T. B.: Disc. Bunting, R. W., and Palmerlee, Faith: Rôle of Bacillus Acidophilus in Dental Caries, J. A. D. A., 12:1411 (April) 1925.

ADMINISTRATION OF SYNTHETIC CARBON DIOXID IN DENTAL OPERATIONS UNDER NITROUS OXID-OXYGEN ANESTHESIA*

By JOHN S. LUNDY, M.D., Rochester, Minn.

THE uses of carbon dioxid have been rather widely discussed in the last few years.[1] † The study of carbon dioxid and oxygen in the physiologic laboratory,[2] and in medical[3] and surgical cases,[4] has resulted in its use in the induction,[5] in the maintenance[6] and at the termination of anesthesia,[7] in the treatment of carbon monoxid poisoning,[8] acapnia,[9] shock and hiccup,[10] and in the prevention and treatment of postoperative pulmonary complications.[11] Henry

*From the Section on Anesthesia, the Mayo Clinic, Rochester, Minn.

*Read before the American Society of Oral Surgeons and Exodontists, Washington, D. C., Oct. 5, 1929.

†Bibliographic references will be found appended to this article.

Hill Hickman used carbon dioxid as an anesthetic for animals about 100 years ago.[12] We now realize that in excessive amounts, carbon dioxid has anesthetic properties[13] and is toxic,[14] but that, in low percentages, it may be used to regulate the volume of respiration.[15] The use of carbon dioxid has become a controversial subject. Certain physicians[16] are enthusiastic in its support and others[17] are not. In 1896, Haldane showed the regulatory effect of carbon dioxid on the respiratory system, and in 1906 and 1925,[18] he again called attention to it. In 1910, Henderson and his coworkers brought out the acapnia theory of shock and the use of carbon dioxid in acapnia.[19] In 1911, Leighton[20] indicated the value of carbon dioxid during anesthesia, applying it clinically through rebreathing, and Lyon[20] demonstrated its effect during anesthesia in experiments on animals. In 1912, Levi[21] reported two years of successful administration of carbon dioxid in cases of respiratory or cardiac failure during anesthesia. In 1920, Henderson, Haggard and Coburn reported on the use of carbon dioxid as a postanesthetic and postoperative measure.

In 1924, Henderson pointed out the use of carbon dioxid during anesthesia. He referred to Sword's clinical use of it in 1923.[22] In 1925 and 1926, he again emphasized the use of carbon dioxid during anesthesia. In September, 1925, I called attention to the value of carbon dioxid in the anesthetization of children in dental operations. Foregger was the first to make a gas machine with a definite control on it for carbon dioxid. Much of the early history of the clinical use of carbon dioxid may be traced to the early owners of that apparatus. I understand that Ecker, of New York, was the first dentist to use carbon dioxid, and later Goldman and Goldman,[23] Clark, Harms and others[24] began to use it and to disseminate information concerning its value.

In September, 1925, I reported a series of cases seen between July 1, 1924, and Sept. 1, 1925, in which carbon dioxid had been used in induction, during maintenance or at the termination of anesthesia in ordinary surgical operations. In December, 1925, I called the attention of the St. Paul District Dental Society to the use of carbon dioxid in anesthesia. Heidbrink aroused the interest of many dentists by his motion picture demonstration of patients and apparatus while using carbon dioxid during nitrous oxid-oxygen anesthesia. At the present time, carbon dioxid has become more and more widely used,[25] and, in a short time, it will undoubtedly be in common use.

Ordinarily, in anesthetizing patients for dental operations, one feels that there are four essential conditions to be attained: (1) insensibility to pain; (2) relaxation; (3) use of sufficient oxygen to support metabolism, and (4) the use of sufficient carbon dioxid to provide satisfactory depth of respiration.

Five per cent, or less, of carbon dioxid in the mixture in the breathing bag assists in the induction of anesthesia, rendering the anesthetic apparently safer and easier to administer.[26] It makes induction easier and smoother and aids in securing surgical relaxation, possibly by controlling the reflexes.

The essential principle in the technic of the administration of carbon dioxid in nitrous oxid-oxygen anesthesia in dentistry is to give various amounts of carbon dioxid with nitrous oxid and oxygen. The technic is simple. The flow of gases through the gas machine is adjusted so that the breathing bag contains an amount of nitrous oxid sufficient to anesthetize

the patient, an amount of oxygen sufficient to prevent marked cyanosis and an amount of carbon dioxid sufficient to cause the patient to breathe somewhat more deeply than he ordinarily does if nitrous oxid and oxygen are used without carbon dioxid. The average amount of carbon dioxid necessary to produce this effect is a volume of from 1 to 5 per cent of the mixture in the breathing bag.

Large amounts of carbon dioxid (more than 10 per cent) should not be used for a patient who is being anesthetized for a dental operation. It is probably advisable to give carbon dioxid from the beginning of the administration of the anesthetic and to reduce the amount in the mixture if the breathing becomes too deep, especially if the anesthesia is to be short. By the term "too deep breathing," I mean hyperpnea, an exaggeration of normal breathing wherein many or all of the accessory muscles of respiration come into play and there is a heaving motion of the patient's body as he breathes.

Carbon dioxid may be used with any of the anesthetic gases, in sequence or in combination. This is especially advantageous in the anesthetization of children.[27] By the use of carbon dioxid, the time of induction of anesthesia may not be made shorter for a patient who takes an anesthetic easily, but if it is difficult to anesthetize the patient, induction is made much smoother and easier than it otherwise would be. It is not necessary to discontinue the administration of the anesthetic and to reinduce anesthesia, as it is sometimes if the patient holds his breath, becomes anoxemic, coughs excessively during induction, goes through a stage of excitement, is nauseated because of fear or for other reasons or attempts to vomit.

If a general anesthetic must be used in the case of a patient with a weak heart and low blood pressure,[28] it is advantageous to use carbon dioxid in the mixture so that anesthesia may be induced with reasonable assurance that anoxemia will be avoided and that the patient will not hold his breath. It is also desirable when a general anesthetic is to be used in the anesthetization of a patient who bleeds easily[29] or a patient with hemophilia, since it increases the coagulability of the blood. This fact may be of use in other cases also.

I believe that it is advantageous for dentists to have carbon dioxid on gas machines, for they will find it to be a convenience, and sometimes it may be considered a necessity. I know that it would be advantageous to a dentist if he could administer carbon dioxid and oxygen to a patient in whom an untoward reaction developed after the administration of a local anesthetic.

DISCUSSION

Menifee R. Howard, Denver, Colo.: Is the use of carbon dioxid conducive to nausea?

Dr. Lundy: In my experience, carbon dioxid does not produce nausea. The physiologic effect of carbon dioxid is primarily to deepen respiration. It is difficult to breathe deeply and to vomit at the same time. The breathing reflex, to my notion, is the strongest reflex in the human body, and if we can control that reflex, it, in turn, seems to coordinate the other reflexes. I have not seen nausea and vomiting more frequently after carbon dioxid has been used than when it has not been employed.

B. O. Grove, Roanoke, Va.: I would like to ask Dr. Lundy if he uses it in connection with ethylene, and if so, what percentage he would advise?

Dr. Lundy: It makes little difference what anesthetic agent is used. The control of respiration is a separate problem from that of anesthetization. Little, if any, space is sacrificed in the bag for the addition of carbon dioxid. The amounts of carbon dioxid are so small that you simply use the anesthetic agent, and the oxygen, as vehicles to carry the carbon dioxid. Therefore, it makes no differ-

ence whether the anesthetic agent is ethylene, nitrous oxid, chloroform or ether. So far as the carbon dioxid is concerned, one simply hopes to control respiration, to suit the purpose.

C. L. Moravec, Cedar Rapids, Iowa: Do you recommend using ethylene or nitrous oxid in combination with carbon dioxid in a tank already mixed, or do you recommend having it in separate tanks to be mixed as you need it, and if so, at what pressure? How far do you advance the ethylene, according to the number, one, two, three, four or five?

Dr. Lundy: We do use carbon dioxid with both nitrous oxid and ethylene. There is no chemical test for carbon dioxid in the blood stream that is so delicate as the physiologic response of the respiratory center to an increased amount of carbon dioxid in the blood stream, and it is best to observe only the patient and use just enough carbon dioxid to bring respiration to a satisfactory depth. On any piece of apparatus that you may be using for the purpose, you simply add about 5 per cent of carbon dioxid as a maximum of the total flow of the several gases. If you were using an apparatus which would indicate the flow in, say, gallons per hour, and if you were giving 85 gallons of nitrous oxid per hour, and 5 gallons of carbon dioxid and 10 gallons of oxygen, you would then have both the flow and the percentage, but in the use of carbon dioxid, on all types of gas machines, one need not be particular about the reading of the gage, or whatever may be used to indicate the flow. If you will observe your patient and give not over, say, 5 per cent to begin with, and then diminish the proportion as you go along, you are better off.

M. F. Wielage, Miami, Fla.: If normal breathing is one of Nature's ways to regulate the acid base balance of the blood, is there no danger in prolonged anesthesia with nitrous oxid oxygen and carbon dioxid, of increasing considerably an acidosis present?

Dr. Lundy: We were not using carbon dioxid as an anesthetic, and the amount of carbon dioxid we use during anesthesia is so small that there is no apparent untoward effect. You may limit yourself to 5 per cent or less with safety. My desire that the amount of carbon dioxid administered shall be limited makes me opposed to the use of mixtures of carbon dioxid with oxygen in a single cylinder. It is, to my notion, a necessity that some way be provided on the apparatus so that large amounts of carbon dioxid shall not be used. Large amounts of carbon dioxid are exceedingly toxic. For instance, the best examples of carbon dioxid poisoning that have been cited in literature may be found under the heading of "corn-silo poisoning." The men who tramp down the ensilage finally, because of weariness, sit down to rest and are overcome with the carbon dioxid. At necropsy, the only change that has been revealed so far is that the blood is curdled or coagulated into a fine, black, hard coagulum. It has been shown that a proportion of 40 to 50 per cent of carbon dioxid in the inhaled gas is rather quickly fatal.

Roy S. Hopkinson, Milwaukee, Wis.: Dr. Lundy struck the keynote of his paper when he said, informally, after his presentation, that perhaps the profession would be better off if the gas machines did not have so many numbers on the dials and so many gages. By that I think he meant to imply that if a man was not able to recognize danger signals, he could not expect a machine to do the thinking for him. I have been impressed by the too common usage of oxygen and carbon dioxid purely as an emergency measure. The value of oxygen in connection with nitrous oxid anesthesia for perfect anesthesia has long been recognized, and should not be considered an emergency measure. We should all profit by the observation that Dr. Lundy has made that while we have appreciated for a long time that carbon dioxid in the old method of deep breathing was a valuable respiratory stimulant, that an excess of deep breathing would produce dangerous symptoms is observed by many men, and perhaps his caution that not more than a minimum of carbon dioxid be used as a respiratory stimulant would be well taken and serve as a warning to men not to get too enthusiastic in experimenting with this respiratory stimulant without really knowing what percentage their patients are getting, and being able to recognize those symptoms as indicated by the patients. I wish Dr. Lundy would go into a little more detail as to what symptoms an anesthetist would recognize that would indicate the presence of an over-amount of carbon dioxid in the anesthetic.

Dr. Lundy (closing): The use of carbon dioxid is exceedingly simple, and personal experience with two or three patients will afford more information than I could

give in speaking for some time. If enough carbon dioxid has not been used it will be found that the patient can hold his breath or breathe in a shallow fashion. The amount of carbon dioxid in the bag at that moment is not sufficient to cause him to breathe deeply. If too much has been used, if the flow of carbon dioxide into that bag has been too great, the patient will be breathing very deeply, the abdomen will have a tendency to move with it, and all the accessory muscles of respiration have a tendency to work. It will be seen in the throat that the patient is going through the typical efforts of one who is short of breath.

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POSTOPERATIVE TREATMENT OF SURGICAL CONDITIONS OF THE MOUTH*

By P. G. PUTERBAUGH, M.D., D.D.S., Chicago, Ill.

IN this age of rapid advancement in all lines of the healing art, it is natural to expect progressive changes in methods of dental practice. The advent of the roentgen ray a few years ago and later researches in the field of focal infection have brought us face to face with dentistry's intimate relationship with general health problems. Coupled with these, refinement in technic in the field of anesthesia has made possible the performance of surgical procedures which the new vision demands of the rank and file of general practitioners.

Surgery is intensely alluring to the younger men, and students in colleges are particularly fascinated by its possibilities and its practice. I have observed, however, that their interest in the patient's welfare all too frequently undergoes a severe and sudden slump as soon as the operation has been completed. They do not seem to realize that the success or failure of the entire procedure hinges in large measure on the care given the patient for the week or two following the operation.

Modern anesthesia permits the performance of oral surgery operations with little pain or discomfort, but the forty-eight hours immediately following are frequently not what the patient had hoped. It is with the conviction that there exists a crying need for emphasizing closer attention and greater care during the days that follow surgical operations that I have selected this subject for discussion.

In order to deliver high-grade professional service, the surgeon must, first of all, be well grounded in the fundamental sciences. Let us assume that an existing pathologic condition calls for surgical correction. A knowledge of histology and pathology is needed as a foundation. The operation demands that the surgeon be possessed also of a comprehension of anatomy, bacteriology and asepsis, coupled with a familiarity with accepted surgical procedure. After an operation has been completed according to a standardized technic, there exists a wide divergence between the practices of many operators in respect to aftercare. This is the point where failures too often begin. It is here that not only an understanding of physiology, of therapeutics and of pathology is demanded, but also skilful application of such knowledge must be exercised in order to assure an uneventful recovery. As one specific example, a dressing hastily placed without regard to tissue pressure or injury can be the cause of sleepless and pain-racked nights for the patient. On the other hand, carefully adjusted dressings suitably medicated will bring comfort and a restful night.

With the acceptance of the focal infection theory of the production of sys-

*Read before the Odontographic Society of Chicago, Oct. 21, 1929.

temic diseases, the practice of dentistry now includes the performance of many surgical procedures which, although they are generally viewed as being of a minor type, are serious enough that occasionally patients do lose their lives thereafter.

The oldest and most frequently performed minor oral surgery operation is the extraction of teeth, the difficulty in connection with which certainly varies in many degrees. Exodontia includes the simple plucking out of a wobbling tooth that has lost most of its periodontal attachment, as well as the surgical invasion of unexplored territory for malpositioned teeth that are held to be etiologic factors in the production of pain, of neoplasms or of systemic disease.

As my subject is the postoperative care of oral surgery patients, and in order that we may more rationally apply the various therapeutic aids at our command, let us pause for a moment to review briefly the local tissue changes that ensue after the extraction of teeth. If the usual forces are applied during the extraction of a tooth, its periodontal membrane is severed into two portions, one of which adheres firmly to the alveolar bone lining the socket and the other to the cementum covering the root. Thus, layers of periodontal membrane adhere to the root surface of the extracted tooth and to the surface of the alveolar bone. Blood flows into the socket from the torn vessels in the periodontal membrane, and if the saliva is excluded, blood soon fills the alveolus. In about ten minutes, firm coagulation will have taken place; the clot forming a plug which mechanically seals the alveolus. This clot performs several important duties. It seals out saliva and infection; it protects the osseous walls from thermal shock and irritating foreign substances; it prevents persistent hemorrhage from the severed vessels, and it forms a bridge into which new tissue is built to repair the wound.

Within a few hours, reparative processes are put in action. Capillary loops from the remnant of periodontal membrane proliferate a short distance into the clot; new red and white blood cells pass out to carry nutrition and to replace those which are breaking down, and fibroblasts set to work constructing new connective tissue. Conversion of the clot into new tissue progresses so rapidly that it will have attained considerable density within a few days; and within two weeks this newly organized area is completely protected from surface destruction by a layer of epithelium that has extended inward from the periphery of the wound. As soon as the fibrous framework has been completed, osteoblasts appear and begin the deposition of lime salts; and in from six to eight weeks, calcification of the area is well under way. During the time this is taking place, the patient experiences only a slight inflammatory reaction in the area and there is little if any pain. That is the history of normal alveolar repair.

Now let us review a few of the influences that operate against normal repair. Saliva may accumulate in the socket before bleeding has commenced and so dilute the blood that normal coagulation is made impossible. Scanty hemorrhage may produce a poorly formed clot that will shrink away from the alveolar walls. Forcible rinsing of the mouth or flushing of the sockets with a syringe will defeat clot formation. On the other hand, clots that have formed in a normal manner are frequently destroyed by the solvent action of surface colonies of bacteria that are omnipresent in unhygienic mouths. Clots will be destroyed by the employment of hydrogen peroxid or other blood solvents as mouth washes. But I believe

that the most prolific underlying cause of failure of alveolar clots to organize is disease of the periodontal membranes, which is commonly associated with chronic infection about pulpless teeth; and that chronic periapical infection does interfere seriously with the conversion of the primary coagulum into new tissue.

Trouble may be uniformly forecast when the roentgenograms of teeth reveal hypercementosis of roots, or when they are surrounded by a layer of sclerotic bone. Such periodontal membranes do not possess reparative properties sufficient to throw out capillary loops in time to keep the coagulum alive, and putrefaction of the primary clot ensues.

Hypercementosis of the apices, which is common in lower bicuspids (but may occur in any tooth) presents a difficult problem because if the teeth are forcibly drawn through the constricted alveolus, they mechanically strip every vestige of periodontal membrane from the alveolar walls, and there is no possibility of normal healing.

In general, postextraction wounds can be divided into two classes: (1) those in which a normal coagulum protects the alveolus and becomes organized into tissue by proliferating periodontal membrane, and (2) the so-called "dry sockets." The term "dry socket" is applied to any alveolus that does not heal by organization of the primary clot just described. In a dry socket, the remaining layer of periodontal membrane is uncovered and soon dies, bare alveolar bone being thus exposed to the oral fluids. This surface is very sensitive at first, and within a few hours becomes highly inflamed and painful. The pain, of a deep, constant, boring character, is felt at first in the region of the wound but later is referred to both jaws and over the entire side of the face. It is usually tolerable during the day, but is aggravated when the patient lies down and is most troublesome at night, seriously interfering with rest and sleep. After about ten days, the denuded alveolar bone dies and the pain stops. Two or three weeks later, sequestration is completed and granulating tissue crowds the shell of necrotic alveolar bone to the surface.

The rational treatment, then, of postextraction wounds should be directed first toward securing and preserving a well-formed primary coagulum by following these simple rules. Saliva should be excluded by walling off the extraction area with gauze sponges in order to have the sockets fill with undiluted blood. Later, the patient should be instructed to rinse the mouth gently with mild antiseptics every two hours for two or three days in order to keep down surface bacterial colonies which might dissolve the clot or cause it to putrefy. Forcible irrigation or flushing of alveoli with solutions should never be done.

Recurrent and secondary hemorrhages that result from a defect of or injury of the primary clot are the cause of much nocturnal annoyance to the professional man and great mental disturbance to the patient's family. Practically all postoperative bleeding is arrested by topical applications. Gauze is preferred to cotton for all surgical dressings. Moderate seepage of capillary bleeding from denuded surfaces is arrested by direct pressure from gauze pads wrung out of hot water. The combined heat and pressure is the effective agency. Continuous flowing of blood from extraction wounds is arrested by elimination of all clots from the socket and the insertion of a gauze plug moistened with solution of ferric subsulphate (Monsel's) and carried to the full depth of the alveolus, where is is maintained in place under pressure with

the finger for ten minutes. The plug will thereafter be self-retaining for forty-eight hours, when it can be removed easily without provoking a new outbreak. In making the application of solution of ferric subsulphate, the gauze plug is first dipped in the solution and then wrung dry in a plain gauze sponge in order to absorb all the excess solution. The plug will still retain sufficient solution to produce hemostasis.

If the clots liquefy and dry socket develops, treatment must be instituted in an effort to prevent extensive bony necrosis and to alleviate the stubborn pain. When the development of dry socket is imminent, it is important to remove the putrefying material early by sponging and irrigation. Mildly antiseptic dressings are placed to combat the infection and to protect the exposed bone, and local anesthetics are added to control pain.

To review briefly a few of the most reliable drugs for incorporation in such dressings: Anesthetics for the purpose of relieving pain are either quick acting and of short duration, or slow acting and of longer duration. Of the quick acting drugs, procain is the best. It is nontoxic as a dressing and 5 or 10 grains can be employed with safety in a single dressing if desired. It can be dusted or packed into the wound in powder form or incorporated in a paste. It will completely relieve pain resulting from exposed bone within ten minutes. Orthoform, a white odorless, tasteless powder that is very slightly soluble in water, is a useful ingredient in paste dressings for mouth wounds. It possesses local anesthetic properties that last for twenty-four hours from one application, is nonirritating and does not interfere with the process of wound repair. A combination of the rapidly acting procain with the slow acting orthoform gives quicker and more lasting relief of pain from exposed alveolar surfaces than can be secured by the use of either drug alone.

Chlorbutanol is another local anesthetic that has many advocates. It also possesses some antiseptic qualities that make it doubly valuable as an ingredient in dressings. Like orthoform, it is very slightly soluble in water, and when incorporated in dressing pastes, it has an anesthetic effect that lasts for many hours.

Black's study of antiseptics many years ago established the fact that phenol solutions as weak as 1 per cent did serious damage to denuded surfaces and absolutely arrested tissue repair. Therefore, although sound mucous membrane will tolerate dilute phenol solutions, since denuded tissues will not, phenol solutions are not recommended for irrigations in surgical conditions.

Of the many antiseptics at our command, boric acid has stood the test of time and is unobjectionable in saturated aqueous solutions for irrigation purposes or when incorporated in pastes.

Thymol iodid is highly antiseptic and will not devitalize the tissue with which it comes in contact, which is probably due to its being very slightly soluble in water. Thymol iodid is employed in pastes in proportions varying from 1 to 5 per cent. It is a more potent antiseptic than iodoform and does not have an objectionable odor.

An ointment composed of 10 per cent procain and 5 per cent orthoform for the purpose of relieving pain, and 3 per cent thymol iodid as an antiseptic, incorporated in a laolin (hydrous wool fat) or even a petrolatum base will usually fill the requirements for a dry socket dressing.

When the osteitis has been growing steadily worse for four or five days and it is evident that the exposed surface of

bone will inevitably die as the result, the foregoing paste will not relieve the pain. In such cases, the operator should hasten the death of the bone and, subsequently control the pain by first absorbing all moisture and then flooding the open alveolus with cauterant remedies, such as a 10 per cent aqueous solution of silver nitrate. As you all know, silver nitrate has a great affinity for nerve tissue, and in these stubborn cases, the relief it affords is almost magical. Of course, the cauterization of an alveolus always means an open socket for several weeks; therefore, it should not be done unless the inflammation has become so acute that necrosis is inevitable.

Another class of surgical wounds result from the removal of impacted or embedded teeth and from cyst operations, etc., that leave excavations in bone. It is manifestly impractical to collapse bone cavities, and as it is highly unsurgical to attempt to suture soft tissues over open bone cavities, all such excavations are left by the surgeon with free and ample access and are subsequently treated as open wounds, to heal by granulation.

Very bland solutions and dressings are employed in these cases. Warm 4 per cent boric acid solutions are used to irrigate and cleanse the wounds and benzoinated lard or mentholated vaselin (petrolatum) is used to impregnate the gauze dressings for the purpose of protecting the denuded surfaces from saliva and food. If considerable odor of putrefaction develops from disintegrating exudate about the dressings, compound tincture of benzoin or balsam of Peru on gauze is substituted for the paste dressing. Rotation of dressings is often comforting to the patient and seems to be effective in preventing putrefaction and for controlling pain and soreness. Open wounds in the mouth should be irrigated and dressed daily for the first week, care being taken that dressings snugly fill the wounds yet do not exert undue pressure on their walls.

During the first ten days, the wound surfaces present a gray hue from coagulated lymph. As soon as active granulation has begun, the gray is supplanted by a healthy pink. At that time, all pain vanishes and 30 per cent bismuth paste in petrolatum may be substituted for the gauze dressings. The patient need be seen only once a week now for irrigation and renewal of the bismuth paste dressing until the cavity is obliterated. If granulation slows up at any time, it can be stimulated by painting the surface with 10 per cent silver nitrate solution at weekly intervals.

Although many vehicles for oral surgery dressings have been suggested, a satisfactory one is yet to be devised. Petrolatum is the only one that possesses the right consistency at room and body temperature; however, it is insoluble in the body fluids and so thoroughly envelops all water soluble drugs that they are rendered almost inert through their inability to reach the tissues. Lanolin and cocoa butter combinations are far superior to petrolatum in this regard, but their consistency is extremely difficult to maintain at varying degrees of temperature. They are slowly absorbable and do not prevent the ingredients in the dressing from reaching the surfaces of the wound for which they were intended. Liquid preparations soon wash away, become foul and fail to protect the wounds. Preference should be given to slowly soluble ointments that will thoroughly impregnate gauze strips or tampons, and all dressings should be gently tucked in place after the denuded surfaces have been carefully cleansed and dried.

Routine treatment following all operations that permit of complete obliteration of dead spaces and coaptation of the overlying soft tissues with sutures is to prescribe a mouth wash of the liquor antisepticus variety, with directions for the patient to dilute it with four parts of warm water and rinse the mouth gently every two hours, retaining the solution in the mouth for a few minutes at each rinsing. This should be continued for three or four days, when the frequency of the rinsings may be decreased.

Sutures in mucous membranes should not be disturbed for five or six days, when they should be removed by snipping with scissors a short distance from the knots and withdrawing with tweezers. Sutured wounds should be inspected at intervals of forty-eight hours, at which time the tissues are wiped clean with small gauze sponges and the surface area and sutures flooded with fresh 15 per cent argyrol solution.

Openings into the maxillary sinus are of two principal kinds: accidental, incident to the extraction of teeth, or intentional, for the purpose of thoroughly treating sinus infection. The practice of filling the sinus with gauze dressings in now obsolete. In the case of accidental openings, no irrigation or dressing is done other than those needed to keep foreign material out of the sinus, and healing by granulation will ordinarily close the opening without any resulting harm.

In acute empyema, the sinus is irrigated daily with warm boric acid solution, all surfaces being gently flushed and purulent accumulations washed away. A gauze plug is then lubricated with petrolatum and introduced into the artificial opening to prevent its closure before suppuration has been controlled. This plug is omitted and the wound allowed to close after the irrigating solution has returned clear for three successive days.

In the past, we have been entirely too prone to limit ourselves to topical applications and local measures. This was a mistake, for surgical procedures are known to produce systemic reactions, which call for the judicious prescribing of general remedies if we are to safeguard the best interests of our patients. An extensive knowledge of materia medica is unnecessary, but there are distinct indications for a few appropriate remedies.

Internal remedies capable of relieving pain are of the group classed as cerebral depressants. They are very useful in assisting patients over the first few postoperative days when pain is most likely to cause discomfort. They act by preventing perception of pain impulses. In this class, the opium derivatives head the list in dependability, although they cause a very unpleasant drying of the tissues, with constipation, etc., from the stoppage of glandular secretions and arrest of intestinal peristalsis. The opium preparation that seems least objectionable from that standpoint is Dover's powder (powder of ipecac and opium) given by mouth in 5 grain doses, repeated every four hours if symptoms demand it. It is very dependable in relieving pain and inducing relaxation of nervous tension and sleep. Amidopyrin, a synthetic coal tar derivative, is our most potent non-habit-forming general anodyne. Prescribed in 5 grain doses every three hours, it will tide patients over sleepless nights in at least 95 per cent of cases because it relieves pain. It has little hypnotic quality and does not produce the mental confusion that persists for a day or two after the use of other sedatives and hypnotics. Acetanilid compound in 5 grain doses is an old and reliable remedy that will relieve pain in a remarkable number of

cases. It is an excellent adjuvant to amidopyrin.

Infections and painful conditions of themselves reflexly arrest intestinal peristalsis and glandular activity and induce constipation. Inquiry should be made postoperatively of patients regarding the bowel condition, and where indicated, suitable cathartics or laxatives should be prescribed. The various saline waters bottled in convenient form or the official solution of magnesium citrate is indicated in acute fevers; whereas, the milder, slower acting laxatives, such as phenolphthalein, in 2 or 3 grain doses at bed time, should be given in the presence of less acute symptoms. Drastic catharsis should be avoided as it is quite unnecessary and is depressing to patients.

Physiotherapy and hydrotherapy are useful additions to our armamentarium for promoting resolution and adding to our patients' comfort.

Cold applications are most conveniently made in the form of ice-packs, in which finely cracked ice is placed in a suitable rubber bag, which is sealed, wrapped in a towel and applied to the side of the face. Cold applications are used for one purpose only, the prevention of swelling immediately following such operations as the removal of impacted teeth, and reduction of fractures. Cold applications are never used for the treatment of infections.

Heat may be applied in many forms. It is indicated in the presence of infections and for the relief of pain. Heat is never used to prevent swelling, but is always useful in the reduction of swelling that has become established, and is especially valuable in the treatment of infections. Heat causes the vessels in the area to dilate; it speeds up circulation to the part, which washes away the toxins from the overburdened tissues, and when abscess formation is inevitable, it shortens the time of suffering by speeding up tissue reactions and hastening localization of pus. Topical applications of heat give much comfort and are close competitors with drugs in relieving pain.

Heliotherapy, or the combined action of heat and light, has a similar effect to the prolonged application of moist heat, but possesses a distinct advantage in that the dosage is under our control. All rays of the spectrum from the infrared to the ultraviolet have their special advocates, and I predict a more widespread use of each in the near future as we gain a fuller understanding of their respective values.

The fact that our patients are ambulatory should not encourage us to neglect any of the little postoperative aids that may contribute toward making their recovery uneventful and as comfortable as possible.

SHALL CARDIAC OR RESPIRATORY STIMULATION BE EMPLOYED IN COLLAPSE?

By W. I. JONES, D.D.S., Columbus, Ohio

FOR many years, it has been the opinion of physicians and dentists that the "last heart beat" was the immediate forerunner of death. Indeed, so long has this been the belief that it has become almost a tradition, and the practice of first applying cardiac stimulants instead of respiratory in cases of collapse is almost universal, this being done on the assumption and belief that cardiac failure is primary.

I am convinced by a wide clinical experience in the administration of anesthetics and by animal experimentation that this procedure is open to question, and is indeed not the best practice, especially in cases of collapse during or after administration of general anesthetics such as ether, nitrous oxid, ethylene and ethyl chlorid. I mean that collapse during or following administration of an anesthetic is more often the result of respiratory failure than of cardiac failure. This does not, of course, apply to those cases of collapse usually termed shock that are directly due to loss of blood or surgical trauma.

It is my opinion that, in collapse, the primary condition is usually the failure of the respiratory center, and the venosity of the blood and the stopping of the heart are only the consequence.

In support of this contention, I submit a series of experiments that were conducted on dogs and were undertaken for the purpose of ascertaining the primary cause of death when nitrous oxid is given to a lethal degree. Some of the animals were given ether, chloroform, ethyl chlorid, bromoform and A. C. E. mixture (a mixture of alcohol, 1 part, chloroform, 2 parts and ether, 3) previous to the administration of nitrous oxid.

Nitrous oxid was the anesthetic most directly in question, but as the other agents named, especially ether, were used in some of the experiments lasting for several hours, and in which the phenomena and end-results were the same, the conclusion is that all anesthetic agents respond to the same antidote, oxygen, and that a death from anesthesia which is conceded to be purely so and one in which surgical shock or loss of blood are not factors, is most likely to be the result of oxygen deprivation; in other words, the use of too much of the anesthetic agent, and too little oxygen to supply the demands of the respiratory pigment, hemoglobin.

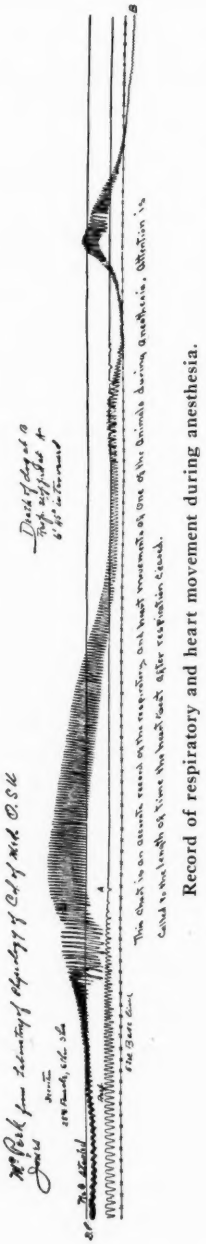
During anesthesia, the respiratory efforts, and hence the absorption of oxygen, may be interfered with in various ways. Some obscure defect in or around the air tract, paralysis of the crico-arytenoid muscles, rough handling of the patient, laryngeal spasm from concentrated doses of ether and faulty position of the patient on the operating table or chair are all contributory to faulty respiration and consequent deoxygenation of the blood. The statement often made

that nitrous oxid and chloroform have a selective affinity for the heart muscle is purely an academic one and is not based upon scientific facts.

The experiments here recorded were performed in the physiologic laboratory of Ohio State University College of Medicine, by Clayton McPeek, assistant professor of physiology, and me. The object was to determine which was the first to cease functioning when nitrous oxid is used to a lethal degree, the respiratory apparatus or the cardiac. In other words, which precedes collapse, "the last breath" or "the last heart beat"? In all of our experiments, the same phenomena were present in every case, i.e., when surgical anesthesia was induced and maintained, a beautifully rhythmic pulse and respiration were the result; but when oxygen was shut off and nitrous oxid was used for the express purpose of producing the death of the animal, the blood pressure was suddenly increased, the respiration became more rapid and finally death ensued from asphyxia. In one case, the heart continued to beat for six minutes and forty-five seconds after the last respiratory gasp. As resuscitation was possible after the cessation of respiration, and was repeatedly carried out on a number of dogs, the conclusion was reached that the viability of the respiratory center is less than that of the cardiac center.

Several of the dogs had one or both of the vagus nerves severed. Death from a too rich mixture of nitrous oxid showed the same characteristics, although impulses were no longer able to travel over the vagus.

The dogs were taken irrespective of age, sex or previous condition. Some had been used as subjects for physiologic experimentation, having had a half dozen or more drugs injected, and being under



Record of respiratory and heart movement during anesthesia.

ether or chloroform anesthesia for as long as three hours. Others were taken fresh from kennels.

Experiments were conducted on thirty different animals, accurate graphs being made of the respiration and the heart beats in each case. Owing to the fact that it was possible to resuscitate a dog after respiration had ceased, and as the heart continued to function in every instance after respiration was at an end, the conclusion was reached that whenever death ensues in connection with the use of nitrous oxid-oxygen, it is due to asphyxia.

The independent resistant quality of the heart muscle to oxygen deprivation must be considered as a favorable feature. According to the experiments of Bert and Martin, death results from a lack of oxygen rather than being due to the presence of nitrous oxid. This is in harmony with our own findings. Gwathmy and Baskerville say of their experiments on animals with chloroform, "We have failed to see a death from chloroform in which the respiration did not cease before the heart."

In fact, one is forced to the conclusion, after much clinical experience and many laboratory experiments, that, in the administration of all inhalation anesthetics, the respiration is the most important index.

The question arises as to what one is to do when he sees respiration depression approaching. The answer is: Use less anesthetic and more oxygen or atmospheric air. What can be done in case of cessation of respiration? Artificial respiration should be given, together with a 5 to 10 per cent mixture of carbon dioxid with oxygen. Carbon dioxid, not oxygen, is the physiologic stimulant of the respiratory center. The use of pulmotors and the hypodermic injection of drugs are of little value.

327 East State Street.

OF WHAT VALUE ARE LABORATORY EXPERIMENTS IN JUDGING FILLING MATERIAL?

By MAX KULKA, Vienna, Austria

THE method, so frequently employed in our specialty, of experimenting in the mouth of the patient has many drawbacks, and many a dentist has had to pay for his opinion as to the quality of a filling material by a loss of practice.

The attitude of the world as regards experiments outside the mouth, which they derisively term "test-tube experiments," is unfortunate, and the idea that one is able, from out the manifold and confusing aspects of vital processes, to draw valid and sufficient conclusions is a mistaken one.

The progress of technical science, based on physics and chemistry, is the result of "test-tube experiments."

It is the method of exact research to isolate a phenomenon and liberate it from the general confusion; in a word, to allow

*From the bureau for testing medical apparatus and instruments at the State Technical Test Bureau, Committee on Dental Surgery.

it to follow its trend, as, in the course of nature, it can never follow it. Thus alone is it possible to discover the abstract laws which govern events and establish truth.

One must therefore undertake reliable tests, easily verified and repeated, and interpret the real process by means of a combination of the previously attained results.

It is high time that far greater use be made in our specialty of this most successful method than has hitherto been the case especially in judging the tooth cements that we use.

The aim of experiments made outside the mouth is to show whether a filling material is actually capable of assuring satisfactory fillings or not, and on the results of these experiments the choice of material should be based. This requires a carefully trained worker, and the experiments must be critically carried out and interpreted. The prejudice which declares that "everything is different in the mouth" must be overcome.

The qualities determined by the experiments afford absolute figures, the interpretation of which, of course, must only be given after careful consideration of the conditions prevailing in the mouth. If, for instance, in a filling, one finds a considerable dissolubility in acids, this must not necessarily lead to the conclusion that this filling is dissolved and disappears in the mouth immediately.

The content of salivary substances which prevent diffusion, the slimy covering of the tooth, which serves as a mechanical lubricant and as a chemical protective stratum, the increased flow of saliva in cases of acid reaction, the possibility, which I first emphasized, for refurnishing the partly corroded phosphates of the filling and the tooth with lime from the saliva, are all factors in hindering the formation of acid in the mouth or diminishing it, the existence of which should *a priori* have been deduced from the fact of the existence, in the mouth, of the tooth, which easily dissolves in acids.

But one thing is certain: In the cases in which acids have a more intense effect, and these cases are very frequent, this filling material, while otherwise showing the same qualities, will be of lesser value as compared to those that are less easily dissolved. Final judgment must, after the critical evaluation of the different figures, be based on the total results obtained. It is also necessary that the methods of measurement and the apparatus give absolutely reliable results.

A well-known author tried to determine the degree of fineness of cement powders by measuring sedimentation in watery suspensions. This method, though correct with regard to powders which are similar chemically and physically, is erroneous when it is a question of heterogeneous substances. Differences in geometric design, weight, friction, deposit of ions, that is, electric charging, the aggregation of water molecules, etc., vary the speed of the sedimentation process in accordance with the size of the grain.

Furthermore, one should limit oneself to the simple measuring of well-defined qualities and avoid hypotheses. The above-mentioned author states that heat reaction produced by the mixing of cements is an indication of the stability of the quantities produced. Apart from the fact that the adage, "A chemical amalgamation or combination is the more stable the greater the degree of heat" is not true, every clear definition of the term "stability" is lacking. What has the formation of heat to do with indissolubility in water, indispensable for cements, the "stability against water"?

Moreover, one can easily obtain exactly the same qualities in cements, while

developing essentially different degrees of heat in mixing or preparing them. If, at one time, one mixes zinc oxid with pure phosphoric acid, and another time zinc oxid with a solution of primary zinc phosphate, exactly the same product is obtained, basic zinc phosphate; while, in the former case, considerably more heat is released than in the second case, where part of the reaction was lost at the outset.

Therefore, the conditions to be fulfilled are: establishment of reliable methods of measurement, a clear definition of that which is to be measured, critical explanation and interpretation of the detailed results in view of the conditions of the mouth, and finally the use of judgment, avoiding all superfluous speculations.

Thus, one may attain results which represent the absolute value of filling material. Propaganda is replaced by scientific research, and the rights of the patient are protected. What is a most important point, progress is encouraged.

Let us not forget that we do not yet possess a really good filling material, though the chemical and physical branches of technical science in all other domains have reached a high degree of perfection.

This is in great measure due to our own attitude, which refuses the assistance of those who wish to work for us and with us. Science and technic must, in this domain, join hands. Success is then sure to come. By maintaining the old method of testing filling materials only in the mouth of the patient and by refusing to examine the materials, we hinder progress.

Therefore, the appeal which must ever again be addressed to our science is this: Let us develop systematic methods of examination; i. e., let us prescribe standards for materials and their examination and let us accordingly sift our materials.

The Journal of the American Dental Association

58 East Washington St., Chicago, Illinois

C. N. JOHNSON, Editor

Published by the American Dental Association

All expressions of opinions and all statements of supposed facts are published on the authority of the writer over whose signature they appear, and are not to be regarded as expressing the views of the American Dental Association, unless such statements or opinions have been adopted by the Association.

Communications intended for publication in the scientific or literary pages of THE JOURNAL should be addressed to the Editor. All advertising or business matters should be sent to the Business Manager.

Subscription is included in the annual membership dues. To nonmembers living in the United States or its possessions, the price is $2.50 a year in advance; Canada, $3.00; Australia, $4.00; other countries, $3.25. All foreign subscriptions are to be paid in United States money.

Editorials

LEARN TO PLAY

One of the really great and essential lessons of life is to learn to play. The man who tries to go through life without indulging in a certain amount of play soon takes on a somber hue that colors and forms his every act. He is never a pleasant companion, never a natural one. People are seldom attracted to him, and children usually shun him. When an individual insists on taking life so seriously that he never gets any fun out of it, he is missing more than half of the real object of his existence.

To play is the natural impulse of every normal human being—at least, to play some of the time. Every child loves to play, every young thing, kittens, puppies, lambs, colts, calves—every domestic animal. Even the wild ones love to play. Play is an expression of the better element in every one of us; it is a bubbling over of the happy spirit of light-heartedness and content that should be part and parcel of every human make-up.

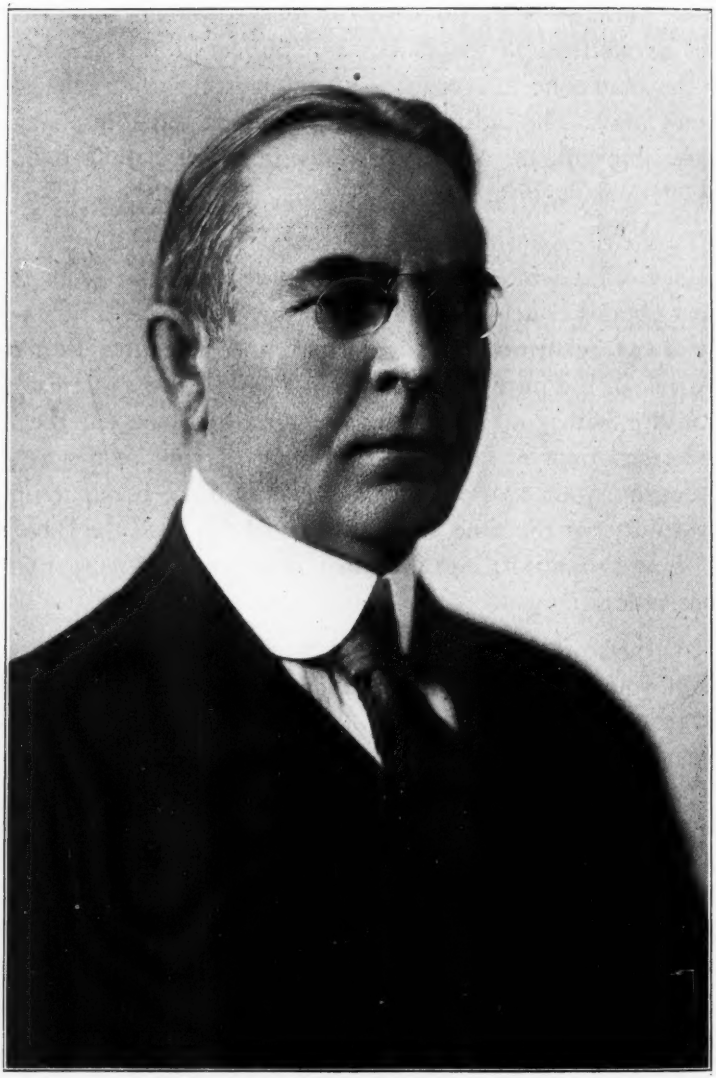
Play is the safety-valve of overwrought nerves, and the solace of tired muscles. Play tunes us for the greater tasks of life, and makes us resilient to the shocks and buffets of fate and chance. Pity the man who affects to go through life without the saving grace of play. The individual who resolutely sets himself against a reasonable amount of play is dangerous—he has deep designs somewhere about him.

To the tired business or professional man, the advice is to let loose once in a while in an utter abandonment that recks not of stocks or bonds or aching teeth. Throw away care for a time—even throw away decorum and all platitudinous precepts. Be natural and drink in the pure air of freedom and hilarity and close companionship with your fellow man. What care you for the hidebound restrictions of custom? Be master of your own soul, your own destiny, your own enjoyment. Shake off the bondage of prescribed duty for the time, the exactions of business, the slavery of routine, and soar aloft into the rarer atmosphere of recreation and expansiveness.

Let the so-called stern realities of life take care of themselves without your aid. Shirk responsibility for once, and learn how sweet responsibility may be when you come back to it. It is almost as great an achievement to learn how to play well as it is to learn how to work well; and it is well-nigh impossible to excel in one without cultivating the other. A steady grind of work is almost deadening to the finer senses if continued too long, just as play would be found unprofitable and would pall if continued indefinitely.

The essential virtue of play is found in the fact that after a period of play and a return to work, the work proceeds with added vim and joy and an altogether greater zest. Work which dragged before goes on with smoother beat and lighter tread, and the difficulties vanish like snow before the summer sun.

Learn to play and know the real joy of living.



CHARLES CHANNING ALLEN
(1862-1930)

GOOD READING

It goes without saying that the professional man should read the periodical literature pertaining to his calling. He should also read the classics of general literature—Emerson for philosophic thought, particularly his essay on "Compensation"; Macaulay for style—his account of the trial of Warren Hastings; a good novel now and then; and Shakespeare for all the heights and depths of human emotion and experience. No man is well read who is ignorant of Shakespeare. He, more than any man who ever lived, sounded the inner secrets of life; the motives of great men and small, the charm of woman, the sublimity and depravity of human kind, and the mainspring of every act. Read Shakespeare and know the essence of real life.

CHARLES CHANNING ALLEN, D.D.S., F.A.C.D.

(1862-1930)

Charles Channing Allen was born May 13, 1862, at Butler Center, Iowa; died July 16, 1930, at Kansas City. He received the degree of D.D.S. from the Kansas City Dental College in 1894, where he was appointed instructor in technics in 1898. He became secretary in 1903, a position which he held until the school consolidated with the Western Dental College in 1919, when he became dean and trustee of the consolidated schools. At different times, he served as president of the Kansas and Missouri state dental associations, National Association of Dental Faculties and the Odontographic Society and as vice president of the American Dental Association. He was an honorary member of the Oklahoma, Texas and Wyoming state societies.

Dr. Allen was a man of rare and commanding genius. He had great literary ability and was an original thinker. Had he devoted himself to literature, he would inevitably have made a name for himself in the world of letters. While he always had the courage of his convictions, he was an affable and a most agreeable companion and enjoyed a wide circle of friends who were sincerely devoted to him.

As an educator and teacher, he was clear-headed and conservative. No student ever went out from under his supervision without being imbued with the sanest doctrines and the highest ethical principles. He always stood for the best in his profession and never failed to defend the good name of dentistry. He lent distinction to his calling and his impress will be felt not only on this generation but also on those to come. If dentistry had more men like C. C. Allen, it would be a better profession.

BUREAU OF DENTAL HEALTH EDUCATION

RECENT INVESTIGATIONS IN PROPHYLACTIC ODONTOTOMY BY THE HYATT STUDY CLUB*

By T. P. HYATT, D.D.S., New York City

THE interest aroused by the publication of statistical findings showing the ratio of liability of the different surfaces of the teeth to caries leads to the desirability that investigations be made by a group of men as to what would constitute a desirable technic in operative procedures for the prevention of decay.

In the fall of 1927, at the request of many friends, a group of men met and organized a study club. The organizers were O. J. Chase, William N. Frazer, John T. Hanks, LeRoy L. Hartman, Arthur M. Hunter, Thaddeus P. Hyatt, Thaddeus Hyatt, Alfred Walker and Maurice William. M. Diamond, B. Clug, C. F. Bödecker, H. Shirley Dwyer and W. B. Dunning also joined.

The regular monthly meetings were productive of much interesting discussion, and certain more or less established data were formulated as a working basis, as follows:

1. That enamel is the hardest tissue in the human body, composed for the most part of inorganic substance, and that its chief function is to serve as a protective covering for the more vital tissues of dentin and pulp against bacterial, mechanical and thermal irritants.

2. That the enamel is completely formed prior to the eruption of the tooth, the enamel-producing cells, the ameloblasts, becoming completely atrophied, and that, for that reason, the enamel, unlike the dentin, does not possess the very important property of repair.

3. That constitutional conditions will institute changes in the dental tissues and particularly nutritional deficiencies and parathyroidal dysfunction, in that the bodily reserve of calcium salts may become diminished and may thereby cause the calcium content of the dental tissues to diminish, lowering their general tone and perhaps making them more prone to bacterial invasion.

4. That the smallest opening in the enamel is conducive to a bacterial invasion and colonization.

5. That pits and fissures are natural defects, evidences of improper coalescence of the primary parts.

6. That, on the basis of statistical evidence of an examination of about 19,000 mouths, by far the largest number of cavities have their origin in pits and fissures. (For that reason, the adjective precarious was prefixed to pits and fissures by the unanimous consent of the club.)

7. That caries appears to progress much more rapidly in dentin than in enamel and therein lies the greatest dan-

*Read before the Section on Mouth Hygiene and Preventive Dentistry at the Seventy-First Annual Session of the American Dental Association, Washington, D. C., Oct. 9, 1929.

ger of precarious pits and fissures, in that the dentin may be appreciably destroyed before there is any marked destruction of the enamel at the point of entrance.

8. That to establish an operative procedure that would eliminate pre-carious pits and fissures would prove to be a definite step in the direction of preventing a large proportion of carious cavities.

On the basis of these data, the following plan of investigation was adopted:

1. To standardize the terminology to be employed in connection with prophylactic odontotomy.

2. To evolve a comprehensive diagnostic procedure for the detection of precarious pits and fissures and to determine the age at which the operative procedure should be instituted.

3. To evolve an operative procedure that will necessitate the removal of the least amount of tooth substance and at the same time secure the maximum amount of protection for the dentin and pulp.

4. To standardize the instrumentarium.

5. To standardize the filling material.

The following committees were appointed: Committee on Nomenclature: O. J. Chase, Chairman, J. T. Hanks, L. L. Hartman; Committee on Procedure and Instrumentation: W. N. Frazer, Chairman, A. M. Hunter, W. H. O. McGehee; Committee on Technic: Alfred Walker, Chairman, J. H. Kauffmann; Committee on Material: Waldo Mork, Chairman, H. Shirley Dwyer, Theodore Peterson, Thaddeus Hyatt. Committee on Progressive Clinic: L. L. Hartman, Chairman, B. Clug, M. Diamond.

COMMITTEE ON NOMENCLATURE

The Committee on Nomenclature prepared a questionnaire, which was sent to the leading men throughout the country and the faculties of dental colleges. The replies received and not received were the most eloquent and emphatic demonstration of the crying need for a better understanding of the English language.

The misunderstanding which has existed regarding the purpose and intent of the practice of prophylactic odontotomy has been related to the misinterpretation of the meaning of certain words, particularly the word "fissure." For some unexplainable reason, dentists had associated with the word "fissure" something normal such as a depression, and had linked " grooves" and "fissures" as synonymous terms. A further investigation by our club showed that incorrect ideas were associated with many terms. "Structure" and "formation" were used interchangeably when sometimes the writer meant "shape" and sometimes "hardness." The word "structure" according to the Standard Dictionary means hardness, softness, compactness, looseness, coarseness, flabbiness, etc., and does not necessarily have anything to do with the shape and formation.

The relation of the structure of the teeth to decay is in regard to the rapidity or slowness of the progress of decay. Hard and well-calcified dentin or enamel will break down more slowly. If the dentin is porous, loosely put together, soft, it will more rapidly break down in the presence of certain acids. Neither the hardness nor the softness of the tooth makes it more liable or less liable to decay.

The liability for decay is not dependent on the structure, but on the formation and on the location of the place attacked.

We must keep certain facts constantly before us:

1. The free acids of the mouth never cause decay.

2. The undisturbed retention of food débris and bacteria at one place for a definite time is necessary to produce acid sufficiently strong to bring about decay.

3. The places which afford retention of food débris but which can be kept clean are the proximal surfaces. The places which afford undisturbed retention of bacteria and food débris and which cannot be kept clean are those surfaces the formation of which constitutes openings in the enamel. These openings are the pre-carious pits and fissures.

After many discussions and investigations, definitions for the following terms were agreed on: developmental line; fissure; pit; supplementary groove; fossa; intercuspal space; formation and structure.

The definitions are as follows:

1. Developmental line: The line of junction denoting evidence of coalescence between the primary parts or lobes. The more nearly perfect the coalescence, the less evident the developmental line. The coalescence between the labial lobes of the anterior teeth and the buccal lobes of bicuspids is usually complete, and the developmental lines or grooves are little in evidence. Evidence of coalescence between the labial and lingual lobes of upper anterior teeth and between the buccal and lingual lobes of upper molars is quite definite. Developmental lines or grooves may be comparable to sutures of the cranial bones.

2. Fissure: A fault in the surface of a tooth caused by the imperfect coalescence of the enamel of the lobes of the teeth. Fissures are therefore usually found along the developmental lines or grooves. They vary in depth. These deformities or faults are most frequently found along the central developmental lines or grooves which unite the buccal and lingual lobes of the posterior teeth and along the developmental lines or grooves which unite the three labial with the one lingual lobe of the upper anterior teeth. Fissures are also frequently found along the developmental lines or grooves which unite the buccal or lingual lobes of the upper and lower molars.

3. Pit: Minute fault of greater or lesser depth having its origin in the incomplete calcification of primary parts similar to that of a fissure. Pits are usually found at the terminal ends of developmental lines or grooves, or at points of intersection of developmental lines or grooves. They may therefore be found on the buccal surfaces of upper and lower molars at the terminal ends of developmental lines or grooves; on the occlusal surfaces of upper and lower posterior teeth at the mesial and distal terminal points of the central grooves or at the points of intersection of buccoclusal and central or linguoclusal and central lines or grooves. They may also be found on the lingual surface of upper anterior teeth along the developmental lines or grooves which unite the three labial lobes with the one lingual lobe.

4. Supplementary grooves: Necessary markings on the enamel, usually radiating from the developmental lines or grooves and frequently obliterated by wear.

5. Fossa: A shallow depression or concavity. There are two types usually met with, the triangular and the circular. The triangular depressions are usually found adjacent to marginal ridges on occlusal surfaces of posterior teeth and lingual surfaces of upper anterior teeth. The triangular fossa on the lingual of the upper anterior teeth is found when a definite transverse ridge is also developed. This transverse ridge is produced by an overdevelopment or overcalcification of the centrolabial lobe in the direc-

tion of the lingual. With a normal development of the centrolabial lobe and an absence of the transverse ridge, the two triangular depressions merge into one even circular or saucer-like depression. Circular depressions are found also on occlusal surfaces of upper and lower posterior teeth, particularly the central fossa of the upper molars.

6. Intercuspal space: A natural space between the cusp ridges of the buccal and lingual cusps of posterior teeth. This space in longitudinal section appears angular, with an angle of varying degrees, formed at the central developmental line or groove by the cusp ridges of the buccal and lingual cusps as the arms of the angle, which lose themselves in the summits of the cusps. Frequently, there is an overcalcification of enamel along the central developmental line or groove, which lifts the developmental line up in the direction of the summits of the cusps, uniting the cusp ridges of the buccal and lingual cusps and forming a transverse ridge, which tends to eliminate the intercuspal space. This is particularly noted on the occlusal surfaces of the lower bicuspids. "Intercuspal space" is suggested to replace the term "sulcus."

7. Formation: As used in its relation to the teeth: the manner in which the structure of the tooth is shaped or fashioned.

8. Structure: As used in relation to inorganic matter: texture, grain, fineness, coarseness, hardness, softness, etc.

REPORT OF COMMITTEE ON TECHNIC FOR CLINICAL EXAMINATION

The Committee on Technic for Clinical Examination submitted the following outline for examination technic in the detection of pre-carious pits and fissures:

Because of the importance of the earliest possible detection of precarious pits and fissures, for the practice of prevention of dental caries, the examination must be most thorough. It should not be hurried and should be considered an indispensable part of a complete mouth examination.

The following are the surfaces in which precarious pits and fissures are more frequently found: Buccal surfaces of lower molars; lingual surfaces of upper molars; lingual surfaces of lateral and central incisors; occlusal surfaces of molars and bicuspids.

The armamentarium should consist of suitable explorers (Graffrath's No. 0-1-2-12), mouth mirror and magnifying glass (either hand or binocular type). There should also be provided means for drying and preserving dryness, i.e., cotton rolls or napkins, or both, compressed air and saliva ejector, and a suitable chart for recording, preferably one printed with red ink for the purpose of contrast in marking.

Precarious pits and fissures can best be detected immediately after a careful and thorough cleaning. It is well to follow a definite plan in order to include all teeth. Start, for example, with the lower right third molar and continue around to the lower left third molar. Then proceed with the examination of the upper teeth, beginning at the upper left third molar and continuing around the arch to the upper right third molar. A thorough examination may be made by following the foregoing procedure while standing at one side of the chair, and then repeating the examination from a position at the other side of the chair. Unless the examination is made immediately after a cleaning, the teeth must be thoroughly brushed.

The napkins or rolls, or both, as the case may be, are placed around the teeth and the surface is dried, with napkins, rolls or spunk, to be followed by compressed air. The surfaces should then be gone over carefully with an explorer, which should be selected as the one best suited to the particular tooth and surfaces to be examined. The magnifying glass will often (even after careful cleaning) disclose food packed in the grooves, for it must be remembered that they may be so narrow as not to admit the finest toothbrush bristle. This food, of course should be removed, and a simple method for its removal is to pass the point of the explorer alternately along the groove and with considerable force spray a jet of water on the dislodged débris. Should this method not be effective, pledgets of cotton saturated with alcohol and rubbed over the surface may prove helpful. Having cleared the grooves of débris, we pass the explorer through the groove and note whether it catches and whether there is any discoloration indicating caries.

If the explorer catches, it may indicate a carious or noncarious fissure, or, it may be, a simple, roughened surface which requires but polishing to prevent caries. It has been shown that a carious fissure may be so fine that even the fine pointed explorer will not detect its presence, and it is here that the magnifying glass proves its value. These fissures may appear stained under the magnifying glass, in contrast with the uninvolved surrounding structure, or, when thoroughly dried, may appear as a thin white line which, when carefully scrutinized, shows clearly as disorganized tooth structure. The same careful examination should be made for the detection of pits.

It is important to examine the explorers from time to time during the examination. For even though we begin with sharp pointed instruments, they may become dulled or the point broken, and it is of the utmost importance that we maintain fine, sharp points at all times.

In conjunction with the foregoing technic, the use of disclosing stains to be developed later should prove of value in the examination for pits and fissures.

REPORT OF THE COMMITTEE ON FILLING MATERIALS

The committee on filling materials for pits and fissures made the following report:

It is the opinion of your committee on filling materials that the best material for filling all pits and fissures or permanent teeth is gold foil. The second best is amalgam.

Your committee thoroughly disapproves of silicates and cements for the reason that they are not permanent.

We have learned of silver nitrate combinations that have come highly recommended, but on investigation from the best authorities, it seems they cannot be regarded as anything more than a temporary procedure. Fillings of the silver nitrate combinations sometimes endure for as long a period as two years before any ill effects are discovered.

We do recommend, however, in the case of teeth not fully erupted (when the rubber dam cannot be applied), the application of silver nitrate with cement filling; and later when the tooth is fully erupted, replacing this filling with gold foil or amalgam. In the case of temporary teeth, amalgam, copper amalgam and silver nitrate combinations are advisable.

Your committee tried to get information regarding tin and tin cement as a filling material for pits and fissures, but could find no one sufficiently qualified to furnish reliable information.

Regarding tin filling, W. B. Dunning has agreed to present a report on this material and to demonstrate its use and practicability. Undoubtedly this material is of great value and because of its simplicity of technic and durability, it will once again become more widely used in this type of work.

REPORT OF COMMITTEE ON CAVITY PREPARATION

The recommendations of the committee are confined to the treatment of precarious fissures found on the occlusal surfaces of the bicuspids; the occlusal and buccal surfaces of lower molars; the occlusal and lingual surfaces of upper molars, and the lingual surfaces of upper incisors.

If a fissure is found in the central developmental line (groove) of an upper bicuspid or a lower second bicuspid, it should be entered with a No. ½ round bur or a No. 33½ inverted cone bur to be followed with a No. 56 flattened fissure bur. Even though it is found that the fissure does not involve the entire (groove) developmental line, the developmental line (groove) should nevertheless be cut out its entire length and if the tooth is of the type that has narrow v-shaped triangular developmental lines (grooves), they too should be cut out.

For the preparation of the margins a No. 242 sugar loaf finishing bur is recommended.

In the lower first bicuspid, when the fissure does not cross the transverse ridge, the treatment should be confined to the mesial and distal pits.

Upper Molar—If a fissure is found in the linguoclusal developmental line (groove) and does not involve the lingual portion of the developmental line (groove), it should be cut out only as far as the linguoclusal margin or boundary, and if a fissure is found in the lingual portion of the developmental line (groove) and does not involve the occlusal portion, it should be cut out only as far as the linguoclusal margin or boundary.

Lower Molar.—If the buccal surface of this tooth presents a narrow v-shaped developmental line (groove), and a fissure is found in any part of it, it should be cut out in its entirety, but if the developmental line (groove) is shallow and rounded, ending in a pit, and the pit only is fissured, only the pit should be cut out.

Upper Lateral Incisor.—When this tooth presents a lingual pit with lateral developmental lines (grooves) or a cervicolingual (gingival) developmental line (groove), and any part of pit or developmental line (groove) is fissured, the entire developmental line (groove) should be cut out.

The committee stated that it had thought to make a recommendation for the practice of immunization, but as the attempt to procure information on the subject had not resulted in that which was either complete or satisfactory, more time was asked to consider it.

CONCLUSION

In the past, we, as a profession have been trained to look for disease, to remove it and to replace the lost part. We must now learn to look for health, for noncarious teeth, and learn what may be done to these teeth to keep them free from decay.

Our study club does not believe we have found the final solution to this problem, and the presentation of our work today is but suggestions offered for your consideration. We earnestly invite cooperation so that our profession can truly become an important factor in public health work.

DISCUSSION

W. H. O. McGehee, New York City: When I became a member of Dr. Hyatt's Study Club, at the time of its organization, I looked somewhat askance on prophylactic odontotomy; and even after I saw some of Dr. Hyatt's statistics, and even after I read some of his articles, I must say that I was still unconvinced as to the advisability of this operation. But after being closely associated with

Dr. Hyatt and with the men who compose this study club and having closely followed their investigations, I stand before you a convert to this operation, with the high sounding, scientific name, but an operation of the utmost simplicity. I am convinced that the term itself has been an unfortunate one as the profession as a whole has been a little afraid of it and so have been somewhat prone to stand aloof from the operation itself. Men have been trying for a number of years to prevent the diseases of the oral cavity, and, in doing so, they have been aiming at two definite and distinct points: the gingival crevice and the enamel. If they discover means by which they could prevent pathologic disturbances in the gingival trough or crevice, and if they could also discover means by which they could prevent the inception of disease processes of the enamel of the tooth, pathologic conditions in the mouth would be largely a thing of the past. We have not been able to do that up to this time. The men interested in preventive dentistry have made progress, of course, but there are still many undiscovered fields in prevention. We are concerned this morning with the question of preservation of the enamel. One of the earliest preventive measures in the profession of dentistry was introduced by G. V. Black, "extension for prevention." Any man who is practicing modern operative procedure today is practicing extension for prevention. This operation was designed to prevent the recurrence of decay around the margins of fillings on the proximal surfaces of the teeth. Dr. Black believed that the majority of these cavities occur on proximal surfaces. We know now, through the statistics which Dr. Hyatt has repeatedly presented to the profession, and through statistics from other sources, that the proximal surface decays are not by any means in the majority, but that pit and fissure decays on occlusal surfaces of posterior teeth, on buccal surfaces of lower molars, on lingual surfaces of upper molars and lingual surfaces of the anterior teeth (more especially the lateral incisors) are the ones which largely predominate. Prophylactic odontotomy is, in view of that fact, designed with the idea of preventing the formation of cavities of decay in these localities where they largely predominate. The profession has not accepted the operation up to this time to the extent that it should have been accepted long ago, owing to the fact that, in the old days, the subject of dental anatomy was not taught in the dental colleges to the extent that it is today. And many of the men in the profession have a misconception of the definition of the terms "fossa," "pit," "groove," "fissure," "sulcus," etc. The subject of dental anatomy in the dental school is receiving a great deal more attention than it did in the past. It should receive a great deal more attention than is given it in some of the schools today. A groove is not a fissure and a pit is not a fossa. They are entirely separate and distinct. Grooves and fossae are natural anatomic markings on the teeth as Nature designs them. A fissure or a pit is a pathologic condition. It is due to the imperfect coalescence or union of the lobes of the teeth, i. e., the centers from which these teeth are developed. In some instances, there is practically a perfect union along a developmental line or groove. In other instances, the union is imperfect, and there the condition is pathologic. Prophylactic odontotomy, then, is designed to take care of these pathologic conditions. If there is a pit or a fissure, operation consists of opening the pit or fissure before it is decayed, because it is going to decay anyway, and, as a preventive measure, placing a filling material in position in order that the tooth may be protected in that spot forever afterwards against the incidence of decay. Dr. Hyatt has outlined the technic of the examination, an exceedingly important procedure. A great deal of time must be devoted to making a diagnosis of the developmental lines or grooves, and determining whether they are defective or are perfectly formed. If they are found defective by use of the magnifying glass and a fine sharp-pointed explorer, the indication is to fill them, before they have an opportunity to decay. Prophylactic odontotomy should be performed as soon after the tooth has erupted as conditions will allow, and the sooner, the better. As Dr. Hyatt stated that, in these cases, the fissure or the pit should be opened with a No. ½ round bur, and that the cavity preparation may then, in the majority of cases, be completed with a No. 56 plain fissure bur. With these two instruments, you can complete the whole cavity preparation in the majority of cases. About 85 per cent of these cases require cavity preparation and filling as indicated. In possibly 15 per cent of cases, the operation of immunization may be attempted. This operation may be divided

into two different types, this depending on the age and the condition found. In some instances, on close examination, it is perceived that the defect does not extend entirely through the thickness of the enamel. In the majority of cases, it is found that it has extended through and that the dentin is affected. In those cases in which the defect has not penetrated the entire substance of the enamel, the operation of immunization may be attempted. In 10 per cent of cases, the immunization operation may be accomplished where indicated simply by starting into the groove or the pit with a No. ½ round bur and going very carefully, not attempting to penetrate the enamel, because the enamel in this case is not penetrated by decay. We then change to a No. 1 round bur, slightly enlarging the opening and then, if necessary, a No. 2 round bur, gradually enlarging the pit or fissure and transforming it from a deep, more or less triangular form, to a rounded form which will become continuous with the surface on which it is located. The operation is then completed by polishing the surface with a fine stone, wood point, pumice and other polishing materials. In the case of very young children, we may sometimes be justified in immunizing by therapeusis. Instead of resorting to the cutting operation, we employ the more or less temporary procedure, of depositing silver by means of the Howe method into the pit or fissure. It is not intended that this shall be a permanent operation; but it is sometimes considered necessary, owing to the age of the patient and other conditions which would not justify cutting. By this alternative, we protect the defective pit or fissure until the patient becomes older, when we may immunize by cutting; or, instead, cavity preparation and filling may be resorted to. I was glad to hear Dr. Hyatt state that gold, cohesive gold, is the material par excellence for filling these cases. There is a revival in regard to gold foil. You who have not been inserting gold fillings had better get back to them, if you are going to keep up with the times. Gold foil has been tested out and it has been proved to be the king of filling materials. You are going to get back to it in your general operative procedure and in prophylactic odontotomy.

Dr. Hyatt (closing): I think it is much harder to make a very small gold inlay than a small gold foil filling. To make a gold inlay, no matter how small, will take more time than it does to prepare the cavity and fill it with gold foil. With the inlay, you must make the wax model, invest it, dry out, cast, polish and then cement it. I doubt if this can be done in from ten to fifteen minutes; that is, including the entire operation. We have members in our club who can prepare a small precarious pit or fissure and fill it with gold in less than twelve minutes. Realizing the difficulty of making a very small wax model of a small cavity, men would be tempted to increase the size of the cavity and thus cut away more of the tooth than is needed. When you find a deep narrow groove in which the explorer will wedge, you have an anatomic formation, so narrow that the bristles of the toothbrush cannot clean it out. This increases the liability of this location to decay. We should understand that a tooth is made of the substance which will always react in the presence of acid. Therefore, we cannot speak of a tooth's being immune to decay. Every tooth and every surface of each tooth is liable to decay in the sense that if acid is present, the inorganic salts of which the tooth is made are bound to react. This is simply complying with a law of Nature. This being true, there can be no such thing as immunity. We must, therefore, look for other reasons to explain why some areas rarely, if ever, decay and other areas frequently decay. Even if what Dr. Bödecker said about expectant mothers is true, is it not strange that in an examination of more than 30,000 cases, we have never yet found a carious cavity in the enamel of the lingual surfaces of the lower anterior teeth? We have found fillings there, but this has always been in teeth from which the pulp has been removed. As the substance of the tooth is susceptible to the action of acids, we must recognize that every tooth and every surface is susceptible. It is therefore not a question of immunity or susceptibility, but rather we should study the condition which will increase or lessen the liability of certain locations to caries. We must recognize at once that anything which makes for the undisturbed retention of materials favorable to bacterial development and growth and thus the production of strong acids increases the liability of caries. Someone has asked regarding the value of roentgen-ray pictures. It is exceedingly doubtful that roentgenograms will show a pre-carious pit or fissure in the occlusal surface of a molar or bicuspid. It may be possible to discover some substance

which may be precipitated in one of these pre-carious pits or fissures which will show up when a roentgenogram is taken. At present, we know of no such substance. Copper cement is good for temporary purposes. Regarding the term "prophylactic odontotomy": I should like to be able to tell you that I coined that name. I believe the name has been the most valuable asset to the entire idea of taking care of these small openings in the teeth before decay occurs. The name has aroused ridicule and criticism. Without ridicule and without criticism, a good thing seldom arrives. The ridicule and the criticism have advertised prophylactic odontotomy throughout the entire world. In Egypt, it is known. In India, they are printing in Sanskrit this phase of preventive dentistry. It is known in Greece, Portugal, Norway, Sweden, Belgium, Holland, Mexico and Canada and elsewhere. I know of no other one subject that has traveled around the world with greater rapidity and has attracted more attention than the term prophylactic odontotomy and the ideas that go with it. Dr. Quimby, of Boston, suggested the name of prophylactic odontotomy. Last summer while in Holland I met someone from Germany who used an expression that I think quite delightful. He told me that as soon as the little children come to kindergarten the mouth is examined and whenever a little tiny hole is found, it is made "no hole." This is the importance of prophylactic odontotomy, namely, to fill the little holes in the enamel before caries starts. To make the little hole no hole. Let us as a profession be more intelligent than the bacteria: let us get there first, and thus keep the bacteria out.

PROPHYLAXIS: THE OUTSTANDING DEFICIENCY IN DENTISTRY TODAY*

By WALTER LEABO, D.D.S., Shreveport, La.

THE term "prophylaxis" as used in medical practice today is generally conceived to mean any measure intended for the prevention of disease. In dentistry, prophylaxis in its broadest sense covers such a wide field that there are few operations performed that do not have in some degree a preventive significance; while the vast majority of dental procedures have a direct bearing on the prevention of disease. It is the intention here to discuss more particularly the routine prophylactic care of the periodontal tissue, with special emphasis on the gingival margins and crevice.

During my own experience in the practice of dentistry, most of the literature, and probably 95 per cent of the teaching, have been along the lines of combating caries of the tooth, together with a prosthetic technic for the restoration of lost teeth. Progress here has been marked, and the means at hand for taking care of these conditions are such that few cases may not be successfully solved in the hands of the competent practitioner.

The problem still confronting us is the fact that there are an overwhelming number of individuals who are doing and have done everything they have been told to do by their dentist, who have submitted to all dental service suggested for many years, and still have developed periodontal lesions resulting in the loss of

*Read before the Section on Mouth Hygiene and Preventive Dentistry at the Seventy-First Annual Session of the American Dental Association, Washington, D. C., Oct. 9, 1929.

the teeth with as much certainty as if practically no care whatever had been taken. This is a wail the periodontist hears all too frequently from the patient, and I know that there are many dentists who feel that no matter how proficient they may be in caring for the ordinary operative needs, there is present the constant fear of periodontal disease, disturbing their sense of having properly protected the teeth from destruction.

That there has been a deficiency in the colleges in the matter of thoroughly teaching this subject is a sad fact. I believe that our oral hygiene propaganda is doomed to failure, or at least to discredit, until the average general practitioner learns the importance of doing, and how to do, good prophylactic work; because no matter how diligent the patient may be in carrying out his duties, unless the dentist properly assists with thorough prophylactic treatments, failure is bound to result. I believe that patients are eager for help along these lines which, on a whole, they are not getting, mainly because of our lack of appreciation of what real prophylaxis entails.

We would be more concerned with this operative procedure so commonly known as "cleaning the teeth," did we stop to consider the fact that we are shouldering the responsibility for the prevention of one of the most destructive, if not the most destructive, disease of the dental tissues, periodontoclasia, a disease to which so few individuals are immune that they are the exceptions rather than the rule. When the dental profession realizes what an enormous percentage of the teeth are lost from periodontal disease, much more interest will be shown in the care of the lesions, or at least in the prevention of them. At least as much thought and care should be given to developing a technic for routine prophylactic care as is given to cavity preparation and filling procedures. Unfortunately, it seems that because the development of gingival lesions is apparently such a slow process, there are all too many who are willing to slight the preventive measures necessary or to ignore the incipient symptoms until they are beyond control. That this situation reacts to the detriment of the dentist is an indisputable fact, since such conditions cannot be indefinitely ignored or treated as of slight importance.

There are two great destructive dental diseases, caries and periodontoclasia. Just what relative part each plays in the ultimate loss of the teeth remains to be determined through the gathering of statistics. Observing practitioners will concede that the latter is at least as destructive as the former during the life cycle of the patient. Caries we believe to be in general a disease of early adult life and childhood. There seems to be a gradual lessening of susceptibility to active caries as age advances, except in the case of pregnancy, when the calcium supply is drawn upon, so that, in later life, most of the dental work required is the repair and replacement of fillings placed much earlier. Teeth lost later in life as the result of caries involving the pulp nearly always became originally involved during childhood or early adult life. So we may confidently say that if a patient comes to the dentist early enough that care may be given carious teeth, and from then on, at regular intervals exercises due precaution, there is every reason to believe, as far as caries is concerned, that the patient will go through life with the natural teeth. But can we say the same regarding the investing tissues, when we consider how little attention is paid to them? Periodontal disease is just as susceptible of prevention and elimination,

in the main, as caries is of arrest and correction, and it is our business to see to it that it is given proper consideration and treatment.

In a discussion of prophylactic care of the gingival tissues, a great deal could be said relative to etiology of the lesions. There is one fact that should be kept constantly in mind: the presence of the tooth is always necessary to the presence of the disease, even though the lesion is of the surrounding tissues. This leads to the conclusion that conditions involving the tooth itself must be taken into account in order that the utmost in protection may be afforded the investing tissues. This entails attention to the proper form of inlays or fillings, occlusion with the opposing tooth or teeth or any other conditions which might act to the detriment of the supporting tissues, and which may be corrected, or at least minimized. The carrying out of these principles may in many cases cover a wide and extensive field.

It may be said that the crevice, created by the extrusion of the tooth into the oral cavity, becomes the site of irritation, chemical, bacterial and mechanical, resulting later in the development of deeper and extensive lesions. This is especially true in the mouths of those races among whom the greatest perversion of character of foods has taken place, which, in turn, results in perversion of the function of the masticatory organs. Therefore, much of our effort must be directed toward the removal of sources of irritation to the gingivae, and prevention of their reestablishment.

Subgingival calculous deposits are generally believed to be the result of inflammatory conditions, with the accompanying disturbance of circulation, congestion of blood and exudation of serum. Therefore, it becomes necessary to eliminate, or at least minimize, conditions involving the teeth themselves, which may bring about gingival inflammation or a disturbance of the circulation, in order to prevent calculous formation.

Calculous deposits, no matter how small, enclosed within tissue or lying in contact with soft tissue, can no more be tolerated by the gingivae than calculous deposits in such organs as the gallbladder and kidney can remain without disturbance, constant and progressive inflammation, and, frequently, tissue destruction due to secondary infection. It then becomes a matter of the greatest importance to remove the calculous deposits, especially from beneath the gingival margins, if we expect to protect that tissue from infection and loss.

The establishment of proper tooth brushing methods with the object of food removal and stimulation of circulation through gingival massage is an accepted and extremely important procedure. Every dentist should be thoroughly informed as to the best technic for brushing and should be prepared to impart this instruction to his patient in a forceful and impressive way. The failure of patients to cooperate in the matter of home care is frequently the fault of the dentist, in that he failed to impress them properly with the importance of the work, or else was not sufficiently specific in his instructions. Time spent in making certain that this cooperation will be thoroughly carried out is of as much value to the patient as time spent in any other operative procedure. Instructions in brushing should never be lightly passed over, with only casual or general remarks. If only slight consideration is given to this part of preventive work, we have no reason to expect the patient to attach more importance to it than we apparently do.

Prophylactic treatments are here intended to mean the routine service to be rendered at stated intervals for the protection of the dental tissues against disease, but with special reference to the periodontium. It is plainly evident that it is impossible to give single or comparatively short treatments to the patient who has advanced lesions or who has not been in the habit of receiving thorough treatments of this sort; since conditions will invariably be encountered requiring prolonged attention before the patient is a suitable subject for the routine service of prophylaxis.

It is an extremely difficult matter to draw a line of distinction between health and disease of the gingival tissues, unless the symptoms are marked. It is my conception that when we speak of a healthy mouth, we really mean that that mouth is healthy in comparison with another's mouth, which we visualize, or else the oral condition is healthy as compared with the conditions which formerly existed in the same mouth. In other words, we mean that the mouth or dental tissues are in a comparative state of health.

It is distressing to see the great number of patients with well-marked or advanced periodontal lesions who have only recently had the teeth "cleaned" or given so-called prophylactic care, but without being informed of the disease condition. It is impossible to give a patient in this condition prophylactic treatment without first eliminating as much of the pathologic process and its causative factors as possible, and this usually requires prolonged treatment and careful diagnosis.

Prophylactic treatments as such may be given to two classes of patients: (1) children who have not as yet developed any gingival lesions or those few fortunate individuals who have never suffered from periodontal disturbance of any appreciable extent; (2) those patients who have previously had treatment for the elimination of periodontal disease, with a return of the tissues to comparative health. In either instance, the treatment is really for the prevention of disease.

Prophylaxis, at first thought, seems a simple enough matter, yet there are few operations performed which are more difficult of accomplishment. It seems to be generally accepted that such treatments are a matter of a few minutes, fifteen to thirty, spent in polishing the crown surfaces of the teeth and scaling the more evident salivary deposits. Operators vary, of course, in the speed and effectiveness of their work, but it would seem practically impossible to treat a full complement of teeth the gingival tissues of which are in a comparative state of health in less than an hour, if we are to render a service to the patient worthy of the name. There is no service rendered by dentistry for the fee received of more value than thorough prophylactic treatments, and there is no service of less value for the fee than carelessly done work of this kind.

The technic of prophylaxis is subject to wide variation, but there are fundamental principles common to any method or procedure. Drugs are of slight value and have little place in preventive measures. The mouth may be sprayed that loose débris may be removed, and a disclosing solution may be applied. Instrumentation should be systematic in order that each tooth may be completely circled, the gingival crevice being carefully explored to the base in order that all concretions as well as soft accumulations may be detected and removed. For this purpose, suitable instruments are necessary, and the development of a delicate

sense of touch should be the constant endeavor of the operator. Such instruments should be selected as can be inserted into the gingival crevice with the minimum of distention and pressure, and which are small enough to be used as an explorer, and as a curet or scaler when accumulations are found. Instruments of this type may also be of use in detecting an unusual depth of the crevice, or so-called pockets, which denotes periodontal destruction.

As each tooth is circled, note should be made of the condition of the gingivae, as to form and color, which might indicate the necessity of further attention. No examination, other than roentgenographic, affords better opportunity for the inspection of tooth surfaces and margins of fillings than the instrumentation of careful prophylaxis. Calculous deposits of even the smallest size should be removed, and roughened surfaces made as smooth as possible, especially those lying in contact with soft tissue. Polishing and taping, of course, follow instrumentation. However, instrumentation is of the greatest importance, and is most often carelessly done.

The curet type of instrument is suggested, or at least one with the working edge in advance of other portions. This enables the operator to detect accumulations with an exploring movement, and to remove them with either a push or pull motion. The matter of selection is largely one of individual preference. The main thing is to keep in mind what we wish to accomplish and use the instrument which in our hands will best do the work.

Prophylaxis is our most important defense against periodontal disease. It is, in fact, at present our only weapon. Failure properly to perform this service is so disastrous that we are later confronted with advanced lesions, resulting in the loss of many and frequently all of the teeth. Periodontal disease has its inception during early adult life and often in childhood, just after the eruption of the permanent teeth, at a time when patients are looking to us to protect them from dental degeneration, and our service is often all too inadequate. If we are to justify our existence as a profession engaged in the saving of teeth and the protection of health, we must learn to better protect gingival tissues as well as to combat caries.

Medical Arts Building.

PLEA FOR A MORE COMPLETE MOUTH EXAMINATION*

By EDWARD L. BALL, D.D.S., Cincinnati, Ohio

ALTHOUGH the area of the mouth occupies a comparatively small space, reaching forward but a few inches from the tonsils to the lips, we are confronted with disease conditions second to none in incidence. Dental science has convinced us that dental caries and periodontal changes represent the most prevalent diseases known to mankind.

The package library from the American Dental Association affords a wealth of material to review, and many of our most renowned clinicians and distinguished writers have covered the subject so carefully that I can but repeat a few truths relative to the neglected, incipient conditions that are the forerunners of the serious pathologic changes that worry every department of medicine and dentistry.

Listed in our textbooks on diseases of the oral cavity are the following articles on soft tissue infections: stomatitis: simplex, catarrhalis, apthous, herpetic, mineral poisons (mercury, lead, bismuth, arsenic and copper), Vincent's infection, noma, thrush, leukoplakia, leukemia, pemphigus, erythema multiforme, uticaria, herpes zoster, eczema, lichen planus, epulis, syphilitic, tuberculous and many others.

How many of us can recognize three-fourths of these conditions? Then how can we expect the general medical and dental practitioner to diagnose them? Only men limiting their practice to mouth lesions know how difficult a task it is.

Now, if we can picture normal conditions and train members of both professions from this point of view, we shall have the first, the underlying, the most fundamental principle involved in mouth examination. Diseased mouths are so numerous that we are coming to believe these mouths are normal. If the general practitioner would just study the soft tissue around the teeth and the bone at the alveolar crest, many cases of beginning periodontal lesions could be arrested.

Many, many times in any exodontist's or periodontist's office, the patient will say, "My dentist has never suggested pyorrhea although I have gone regularly for dental inspection." Now tell me, isn't this true? Then too, other remarks such as these are too often heard: "Your teeth don't need cleaning." "He said, 'Pyorrhea can't be cured.'" "He never suggested an x-ray." "He just used a brush and white powder."

It is necessary, then, that we see to it that we do not busy ourselves too long with mechanical restorations, leaving no time to heed the warning cry of the symptoms of disease conditions whether they are of the hard or the soft tissues of the oral cavity. The structure of any house depends largely on its foundation.

Look around, investigate the great diagnostic centers of our country. Surely,

*Read before the Section on Mouth Hygiene and Preventive Dentistry at the Seventy-First Annual Session of the American Dental Association, Washington, D. C., Oct. 8, 1929.

there must be some reason for their success. Unquestionably, it is due to their untiring effort, to thoroughness and diligent application to detail.

Justin Towner has so aptly suggested that every dentist be a mouth physician, and with this thought may I lead to my theme: "A more thorough diagnosis."

Our patients, young and old, deserve the same careful, precise and routine examination as is given by a trained medical diagnostician. It is he who asks for a past and present history, who makes a most careful clinical, roentgenographic and laboratory examination. After this routine, he knows that he has some basis for sensible deductions.

Do we allow our patients sufficient time for this type of oral examination? We know full well that our appointment books do not afford us time enough for this service.

Just for comparison, I recently referred to an internist a patient who had suffered from a chronic arthritic condition which baffled many members of the medical profession. This able diagnostician set aside one hour for his first consultation. A complete history was taken, a thorough clinical examination was made. The patient was then referred to a radiodontist for complete roentgenographic examination. She was then asked to return for reexamination in conjunction with all laboratory findings. This internist may fail, but he has at least given the patient the best that could be had in his effort to diagnose her case.

Do we dentists go through this carefully planned routine for all newly referred patients? I am afraid not. Our examinations are usually slipped in between regular appointments and a hurried, unfair diagnosis results. In this short time, are we able to study oral conditions sufficiently to advise patients, or to refer them to physicians for systemic treatment, which is so necessary in cases of many diseased mouths? Do we give our medical friends a careful clinical picture? Surely, they never neglect to recommend us when they find that a patient's teeth are at the root of all the trouble. If physicians are calling for dental consultations, why can't we reciprocate?

May I make my plea now? Give at least one-half hour to each new patient. Make a thorough examination, taking a past dental history. Make inquiry as to the general health and ask the reason for seeking advice.

Now as to the examination: Remember the index fingers are valuable instruments in the procedure. They locate loose teeth and soft gum tissue. If, when they are pressed on the gums, there is an appearance of blood, we know that we are dealing with an unhealthy mouth. We now proceed, using suitable instruments for locating periodontal pockets and cavities. Do not forget to percuss the teeth. Test each tooth for vitality. Take impressions for study models. Periodontoclasia is so prevalent, why not look for it in every mouth instead of the exceptional one? Insist on a complete 14 or 16 film dental roentgenographic survey, and frequently an interproximal examination before giving a final opinion. And here let me say a few words regarding the roentgen rays.

We have had the roentgenogram for many years as an aid to oral diagnosis but there are still faulty ideas as to its value and uses. They say that a principle that is misunderstood is too often condemned and that one that is understood is overdone. Simply because an x-ray machine exposes a film black and white is no sign that it can be interpreted accurately.

If the clinical side appears to be negative and we are basing our conclusions on the roentgenogram, the picture must be a good one. Hospitals, physicians, medical laboratories, dental laboratories, nurses and dentists are exposing films, many of them of little value.

If the dentist expects to remain a leader in dental roentgenography, he must standardize his technic, which, in the end, will mean better roentgenographic interpretation.

Returning to the examination: We find that the roentgen-ray examination is complete and the films are properly mounted. At the next appointment, with the aid of the clinical history, an intelligent program of oral health is outlined for the patient. He will wish to know the truth: most patients do. Give him straight facts regarding the contemplated procedure. Discuss with him the economic situation. He has a fair chance to accept or reject your services, giving you the same privilege regarding the care of his case. If you fail to do this, he may prove antagonistic, spoiling many well laid plans for a happy routine handling of the case.

Sterling V. Mead says that the following procedure has proved satisfactory: 1. Complaint. 2. History. 3. Manifestation of pain. 4. General oral examination. 5. Percussion and palpation. 6. Exploration. 7. Color. 8. Conductivity of temperature. 9. Transillumination. 10. Roentgenographic examination. 11. Pulp testing by electric current. 12. Bacteriologic examination. 13. Histopathologic examination. 14. Blood examination. 15. General physical condition, temperature, etc. 16. Urinalysis. 17. Serologic test. 18. Differential diagnosis. 19. Treatment recommended.

May I repeat and emphasize these suggestions? Spend more time on your diagnosis. Remember, a complete clinical and radiodontic examination and study models spell intelligent diagnosis. This, I believe, is our responsibility to patients and to those who have so kindly referred them to us.

547 Doctors Building.

CURRENT LITERATURE

EXTRACTS AND ABSTRACTS

Prevention of Heart Disease: Heart disease is the commonest cause of death in the United States, the number of deaths occurring in 1929 being over 225,000. (W. H. Robey, *New England J. Med.,* May 22, 1930.) The control of tuberculosis and other infectious diseases, the earlier recognition of rheumatic fever as it occurs in children, the eradication of infected tonsils and diseased teeth have all contributed to a strikingly lowered mortality from common diseases of children and in their cardiac death-rate as well. As the reduction of mortality in childhood and youth increases the likelihood of death from circulatory affections in the later decades, the preeminence of heart disease as a cause of death will increase rather than decrease as time progresses. Better understanding of the duration of rest and exercise and of proper digitalization will contribute to the well-being and usefulness of the victim of cardiac disease. In the prevention of heart disease, the rôle of antitoxins in diphtheria and in scarlet fever is of great importance. The specific organism of rheumatic fever, which is responsible for much of cardiac disability, has not yet been found. While the world is waiting for its discovery, foci of infection must have earnest attention. Although most articles on rheumatic heart disease place diseased tonsils first among the causes of the condition, various authors have expressed doubt concerning the value of tonsillectomy, asserting that the operation does not prevent subsequent attacks of rheumatic fever. Those who believe in the enucleation of the tonsils consider that the reason for failure of the operation as a preventive is the imperfect or incomplete removal of the tonsils or the fact that repeated attacks have been followed by the establishment of other foci of infection. Regarding the teeth, the author says: "The teeth are less apt to cause cardiac involvement than the tonsils. In the writer's experience, healthy looking teeth are more frequently a source of obscure cardiac infections than the clearly diseased ones. By this we mean that a firmly embedded tooth with an infected root canal is a greater source of danger than a decayed tooth loosely placed in the alveolar process and evident to the patient and his dentist. That infected teeth occasionally are a cause of cardiac pain cannot be doubted. Usually x-ray studies and their competent interpretation are necessary to determine the possibility of root canal infection." Syphilis ranks next to rheumatic fever as a cause of heart disease, especially in the young adult. Early diagnosis and thorough treatment are essential to prevention of heart complications. That the largest number of deaths from heart disease occur between the ages of 70 and 79 is not surprising nor discouraging in that many of these cases are merely the final picture in a general arteriosclerotic breakdown or represent the terminal stage in diseases of other organs. Patients must be urged to have routine physical examinations in order that incipient signs of arteriosclerosis may be recognized; for while this is a progressive degenerative process, its progress may be slow if it is recognized in time. The author closes with a plea that the energies of the physician be bent to a study of the potential case as more important even than the management of the cardiac cripple.

Visible Effect of Castor Oil Soap on Certain Organisms: Data demonstrating the visible changes in density of the suspensions of various micro-organisms when treated with suitable amounts of castor oil soap (sodium ricinoleate) are submitted by R. R. Spencer, surgeon in the United States Public Health Service. *(Pub. Health Rep.,* June 13, 1930.) He found that sodium ricinoleate, in appropriate amounts, completely clears the bacterial suspensions of certain species in a physiologic sodium chlorid solution, rendering such suspensions water clear. The density of suspensions of certain other bacterial species is increased by appropriate concentrations of sodium ricinoleate. The density of still other

bacterial suspensions is increased at one concentration and decreased at another concentration. The explanation of such changes, he states, is not yet apparent. Certain bacterial species will grow in plain broth containing 1 per cent sodium ricinoleate.

Nitrous Oxid-Oxygen in Exodontia: After the administration of anesthetics in more than 42,000 cases, J. H. Beckwith is convinced that nitrous oxid-oxygen is the safest and most satisfactory inhalation anesthetic that is known for the removal of teeth. A general anesthetic he considers superior to a local in view of the fact that a more or less violent reaction or an exacerbation of existing infectious systemic symptoms is liable to follow the use of the latter; whereas, such reactions have been absent or very slight under general anesthesia even when a large number of teeth have been removed. The author has seen a reaction so violent following local anesthesia that a seemingly strong patient has been forced to spend a week in bed; whereas, a bedridden patient has been taken out of a hospital and had all the teeth removed under nitrous oxid-oxygen, and even with much apical and peridental involvement, no noticeable reaction took place. After checking up results from hospital records, the author is convinced that a local anesthetic should never be used for the removal of a diseased or impacted tooth. Of the general anesthetics, nitrous oxid-oxygen is advocated as quick in action and pleasant to take. Of all anesthetics, it causes the least reaction. It therefore is advocated for the weak and debilitated. It is indicated in the handling of patients with anemia, high blood pressure and diabetes, and in pregnancy, and also in child cases. No tissue or chemical change takes place. However, skill and experience is necessary for the safe and satisfactory administration of this anesthetic. The anesthetist must be able to recognize every symptom connected with the anesthetic state, and must translate correctly the types of breathing, the color and the facial reflexes, especially those of the eyes. During removal of the teeth, the patient is placed in an upright position in the chair. The author warns against simply placing the cone over the nose and setting the gas machine at a certain per cent as each case is a different one. He believes that the use of ntirous oxid-oxygen, properly given, will be unattended by shock, secondary infection and after pain.

Treatment of Trifacial Neuralgia with Alcohol Baths: In thirty cases of trigeminal neuralgia, Nasaroff *(Deutsch. Ztschr. f. Chir.,* April, 1930) has resorted to moistening the carotid artery with an 80 per cent alcohol solution. In every case, some good effect was attained, either a marked lessening of the pain or almost complete cessation. In some cases, the pain ceased while the patient was on the table; in others, not until toward evening of the day of application, and occasionally not for two weeks afterwards. He stresses the importance of thorough moistening of the artery even beyond its bifurcation. He feels that this method should be given preference over alcohol injection and operation.—Abstr. *J. A. M. A.*

Suppuration in the Paranasal Sinuses as a Factor in Focal Infection: In a review of the histories of 400 cases, sinusitis was found not to be a factor in focal infection, by C. M. Anderson (J. A. M. A., June 14, 1930). Teeth, tonsils, the prostate gland and other foci were found to be of more importance. Suppurative sinusitis may be a focus of infection on rare occasions. In a patient with a nose normal on clinical examination, and with a history negative for diseases that can be referred to the nose, any exploration is not justified. Unnecessary trauma reduces the resistance of the membrane and may introduce infection. Toxins are absorbed by the blood stream, but bacteria are rarely transmitted to distant parts of the body from paranasal sinuses. Existing infection of the nose and paranasal sinuses should be treated in the most conservative manner consistent with the complete eradication of the disease.

Scotch Oats and English Chaff: The results of scientific experiments recently published by the Medical Research Council have demonstrated that certain foodstuffs—notably oatmeal—have a definite anti-vitamin effect. Somewhat jocularly concern was expressed by an English doctor in the House of Commons at the effects on the health of the people of Scotland through the great use of oatmeal in our country. Equally jocularly porridge was defined by the Government representatives of the Scottish Office. The fact is that oatmeal is a good body-building food only when it is taken with plenty of vitamin D, as in haggis (where liver supplies the vitamin), or in bannocks and butter, or porridge and cream (where the vitamin is provided by the butter or cream). But if vitamin D was the

subject of a jest in Parliament, it is a matter of grave concern that so many Scottish mothers and children are undernourished and sun-starved—in other words, suffer from a deficiency of vitamin D. It is no exaggeration to say that if every mother throughout pregnancy and every child from birth to school-leaving age received a sufficiency of vitamin D, we should add inches to our national stature; and this country, instead of having almost the worst teeth in the world, would have the best. Everything points to the medicine of the future being largely pure air, sunlight, and nutrition. Then to the process of human body-building will be devoted more and more of that skill and science which today are reserved for the making of motor cars. The word "vitamin" is now a part of the English language. Unfortunately vitamin D is not yet sufficiently a part of the Scottish diet.—*Scottish Health Mag.,* May, 1930.

The Newer Aspects of Viosterol: Standardization of the potency of viosterol is of great importance and Dr. Alfred Hess made comparison with the potency of cod liver oil. The American standard, 100-D, indicates a potency 100 times as great as that of cod liver oil. The difference in the potencies of the original preparations depends on the intensity of the irradiated solvents. Estimate of the degree of potency based on the number of milligrams of viosterol is unreliable: for instance, the 40-D original preparation of France contained 10 mg. and the 2500-D preparation of Germany contained only 10 mg. On biologic tests, it is indicated that the dosage is too low rather than too high. Fortified cod liver oil is cod liver oil to which viosterol has been added, resulting in a mixture with a potency of 5-D. Ergosterol, while found elsewhere in nature, may be secured easily from yeast on account of its cheapness. Irradiated milk, dry or fluid, can be used in place of ergosterol. There is not much gain in irradiating cereals, for two reasons: there is little sterol in cereal to be activated; the most serious time for rachitis in an infant is the first six months of life, during which period an infant receives little or no cereal. Of risk with many irradiated foods, Dr. Hess thinks there is little danger. This new drug cures patients with craniotabes while in certain instances cod liver oil has failed. It stimulates increased production of eggs in fish in captivity. In rickets, as a result of treatment, hypercalcification of the epiphyses is seen in the roentgenogram. True clinical indications for the use of this drug are seen in rickets, tetany and osteomalacia; the last disease is seen frequently in India and China. This substance has been tried in Paget's disease, dental caries, fractures, paralysis agitans and colds, in fact, as a cure-all. The toxicity of viosterol lies in its ability to produce hypercalcemia, but it is not toxic in its various chemical phases. The final product is a mixture, not a photochemical entity. As a result of hypercalcemia, there occurs calcification of the aorta, coronaries, heart, stomach and kidneys. But hypercalcemia is not distinctive of viosterol. Cod liver oil can produce the same result in rats in doses of 300 mg. and in infants in doses of from 3 to 6 teaspoons a day. There is no risk in giving viosterol in the summer months in spite of sun irradiation to the skin. Fortunately, in both animals and the human being, a definite clinical symptom occurs when hypercalcemia is imminent. Loss of appetite is noticed. This symptom gives warning in ample time before damage can occur. These toxic effects were associated with the old vigantol, the potency of which was 200 times that of our 100-D preparations. The margin of safety is very wide with the latter. In Dr. Hess' opinion, the toxic dose is at least 300 times that of the prophylactic or even curative dose.

The therapeutic dose is from 8 to 10 drops a day; 15 drops to cure patients who have rachitis and tetany, and larger amounts to protect premature infants. It must be remembered that idiosyncrasy for the substance occurs, but failing appetite as a gage of overdosage is adequate. Viosterol may safely be given to pregnant women. If there is a negative calcium balance, the woman will not be robbed of her ability to provide the infant with calcium. For such purpose, 20 drops may be given, the dose being divided between the two, but the fetus deriving the greatest benefit.—Alfred Hess, in *Am. J. Dis. Child.,* April, 1930.

MISCELLANY

BOOK REVIEWS

The Fundamental Principles of Alveolo-Dental Radiology. A Textbook Dealing with the Technics of Taking Radiographs of the Teeth and Osseous Tissues of the Human Jaws, with an Analytical Treatise on Their Interpretation as a Basis of Diagnosis of Oral Lesions. By Joseph Andrea Pollia, M.D., Los Angeles, Calif., Senior Attending Physician and Instructor of Internes, Los Angeles General Hospital; Instructor in Nutrition and Diseases of Metabolism, Dental College, University of Southern California; Postgraduate Lecturer on Alveolo-Dental Radiology before Numerous Dental Organizations. 550 pages with 774 illustrations; price, $8.00; published by Dental Items of Interest Publishing Co., Inc., Brooklyn, N. Y. The science of radiology is developing at a very encouraging rate, and the way is a long one from the early days when the pioneers in this field were groping their way through the fog of uncertainty and experimentation to the present with its more definite achievement and its increased reliability. It is rather pathetic to contemplate the errors that have been made through faulty technic and false interpretation, but with it all, the roentgen rays have brought dentistry a very important aid to the most efficient service. Dr. Pollia's book is put forth with an apparent appreciation of the serious obligation that devolves on an author writing on a subject through the medium of which much harm or good may result. He seems to sense the fact that the reader may be expected to take the statements made on faith and to follow them in practice, and, therefore, he is never unconscious of his responsibility in the matter. This has led to a very careful preparation of the work and it may logically be called radiology up to date. The author makes a very significant statement when he says that: "No other branch of radiography demands more attention than does the alveolo-dental." When we think of the many grievous errors that have been committed in the past through misinterpretation of roentgenograms of the teeth and jaws, we can readily accept this statement. In the very nature of things, tissues such as the teeth and alveolar process, with all of the detail necessary for their proper interpretation, present an unusually difficult problem, and the more light that is shed on the subject, the better it will be for the profession and for the people who are served by it. It is altogether impossible to review in detail all of the subjects treated in this volume, but we can refer the reader who is interested in the subject, with all confidence, to the volume itself. It will well repay reading and study.

Dentistry—a Profession and a Business. By A. B. William Suter, D.D.S. 389 pages; price, $7.50; published by Ritter Dental Manufacturing Co., Rochester, N. Y. According to the author, "This book was really written by the dentists of America, and merely compiled by me." Even if this modest statement were strictly true, the fact must stand out that Dr. Suter has exhibited rare judgment and displayed an amazing amount of energy in making his compilation. The purpose of this book, if the reviewer visualizes it accurately, is to link up the business aspects of dental practice with the strictly professional, and in this we think the author has succeeded most admirably. A glance at the chapter headings will indicate the general trend of treatment, and will bring home to the reader what he may expect to find in the text. The following are among the subjects treated: "Some important factors influencing the success of the individual dentist," "Establishing a dental office," "How to select a location for a dental practice," "Arrangement of rooms," etc., decorations and complementary furnishings, ethical publicity, professional and social conduct, business side of practice, partnerships, savings and investments, influencing a patient's valuation of scientific dental service, child patients, dental hygienists and nurses, and the dentist's physical and mental health. To show the author's attempt to emphasize the professional phase of dental practice, he has a chapter on the Code of Ethics

of the American Dental Association, and all through the work, there is an evident effort to stress the professional along with the business side of the dentist's activities. The book is well illustrated, but the cuts are not numbered, which might have seemed advisable for purposes of reference. Dr. Suter is to be congratulated on the preparation of his book, and the Ritter Company on the excellence with which it has been brought out.

Ultra-Violet Rays—Their Application in the Practice of Dentistry. By Robert J. Reade, M.A., M.D., C.M., D.D.S., Toronto, Canada. Price, $1.00. Issued by the Canadian Dental Research Foundation, 312-170 St. George Street, Toronto, Canada. Bulletin 13 of this foundation is an exposition of the present knowledge of the subject as it relates to the work of the dentist. A history is given of the development of the subject so that the reader may make an intelligent approach to its study. Its value or lack of value in the treatment of various diseases connected with the teeth and mouth is dealt with in an apparently conservative manner, and the report is not padded with indifferent or irrelevant material. It is felt that a perusal of this booklet will be found profitable to all of those who are interested in the subject.

INTERNATIONAL DENTAL FEDERATION (F. D. I.)

THE SCIENTIFIC COMMISSION

By Bernhard Gottlieb, Vienna, Austria.

At the international congresses, which are held every five years in our profession, the latest achievements of dentistry are shown. The visitors can generally see here what their colleagues who are engaged in the progressive development in the most varied spheres have to report. The congress is the personal international intermediary between the investigator and the practitioner. At this time, personal contact between the single investigators is made.

This opportunity, which recurs every five years and which should serve both of these purposes, appears to be insufficient, especially for the latter purpose. The pioneer groups of the several nations should have the opportunity of coming in contact with each other much more often. As valuable as literature is as a written medium and as much as the references given in periodicals attempt to furnish information on the spheres of work in the different languages, they are not able to effect a really exhaustive contact between the research institutions of the various nations. A short personal talk in a narrow circle often explains very much more concerning interests and working institutions of the several authors than a tedious study of the respective works. The Scientific Commission of the International Dental Federation offers such an annual recurring opportunity for intercommunication, especially between the investigators themselves. In no case, however, is there a rigid limitation. The scientific transactions of the commission are naturally accessible to every dentist who is interested in them. At the annually recurring meetings, authors from the various countries bring short reports on their original work or on works from their immediate neighborhood on which they have first hand information. Such international meetings in narrow circles offer the possibility of obtaining mutual information on the various objects on hand of original exhibits (preparations and the like) and to further the same. Such a contact, fostered in this way, between the investigators of all countries in the intervals between the congresses has the effect that the reports on the new achievements destined for the congress are presented in a clear and polished form, thanks to the previous direct conferences between the pioneer groups of the various countries.

Apart from this permanent work of the scientific commission of the International Dental Federation, problems from time to time appear which are apt to revolutionize the whole profession. As the example of the question of *focal infection* shows, it can be a matter of problems which arouse the keenest interest. On the occasion of such events, it is very advantageous to have a permanent scientific institution to which representatives of all nations belong. By this means, opportunity is given not only to discuss questions continuously before an international forum, but also to consider and propose measures which are suitable for solving these.

THE COMMISSION ON DOCUMENTATION

By Emil Huet, Brussels, Belgium.

The Commission on Documentation was formed in the year 1909 in Berlin. From that date on, it has never ceased to collaborate regularly in F. D. I. activities.

Its program is briefly stated thus: "The furthering of relations between authors and readers."

It is doing methodical work, following a scheme which comprises, at the same time, the collection, compiling, cataloging and utilization of books, dissertations, etc. The Commission on Documentation has during its activities particularly studied which are the best means to be adopted for editing the analyses, for the biographic notes to be made, for the disposition of tables of contents and other writings in general.

The suggestions made by the Commission on Documentation are not only followed by a certain number of dental periodicals, but also by publications that have nothing to do with the dental profession.

In the course of the last sessions, the commission has concerned itself with the organization of the F. D. I. archives. It has enlarged their domain and has done its best to assure the conservation of all documents in the interest of investigators.

To this end, the commission has established the International Office for Documentation of the F. D. I. In order to give that office a juridical existence, allowing it to receive liberal gifts, that are intended for the collective work, it has been decided to entrust the "Dental Documentary Foundation" with its management. This foundation has been created under the auspices of the F. D. I. and all its resources are intended for the enlargement of the collections.

The Eighth International Dental Congress takes place from the end of July to the beginning of August, 1931, in Paris. Preparations are in full swing. Further information will be given out shortly. Letters are to be addressed to the Secretary, Georges Villain, 45 rue de La Tour d'Auvergne, Paris (9e).

NEWS

Dr. Davis Retires from Indiana University School of Dentistry: It is announced from Indiana University that Sherman L. Davis has severed his connection with that institution. Dr. Davis will continue his work under a new connection. The Foundation for Nutritional Research, which was being organized at Indiana University School of Dentistry, will be abandoned, because of the withdrawal of Dr. Davis. A nutritional clinic will be continued in the school, as heretofore, along the lines which have been so carefully worked out by Dr. Davis.

Vienna's "Mutterschulen": The city of Vienna, Austria, has started schools for mothers in which they are taught about nutrition and nutritional disturbances, infectious diseases and protective inoculation, care of the new-born, and of well and sick children, mental hygiene of children, and the hygiene of sleep. Lessons on children's songs and games and the making of children's clothing may be added. The courses are under the direction of a woman physician and a woman welfare worker.—*Am. J. Pub. Health,* June, 1930.

DEATHS

Black, J. J., Seattle, Wash.; Des Moines College of Dental Surgery, 1901; died, Oct. 1, 1929, of cerebral hemorrhage; aged 60. He is survived by the widow and three daughters, one of whom is Mrs. C. T. Fleetwood, Seattle, a graduate dentist.

Beattie, E. L., Chicago, Ill.; Missouri Dental College, 1891; died, June 22, after a brief illness with pneumonia; aged 58.

LaSalle, B. F., Brighton, N. Y.; died, April 11; aged 98.

Long, Charles J., Rock Island, Ill.; Chicago College of Dental Surgery, 1898; died, June 27, of heart disease; aged 56.

Rogers, Richard, Scales Mound, Ill.; Northwestern University Dental School, 1897; died, April 26; aged 72. Dr. Rogers retired from practice in 1897.

Skinner, Frank H., Chicago, Ill.; American College of Dental Surgery, 1895; died recently, of heart disease; aged 61.

Vasumpaur, John A., Chicago, Ill.; Chicago College of Dental Surgery, 1902; died, May 29; aged 48. He is survived by his widow and a son who is studying dentistry.

ANNOUNCEMENTS*

CALENDAR OF MEETINGS

American Dental Society of Europe, Paris, France, July 29-Aug. 1, 1931.

International Dental Congress, Paris, France, Aug. 3-8, 1931.

International Dental Federation, Brussels, Belgium, August 10-16, 1930.

Chicago Dental Society Midwinter Clinic, Feb. 2-5, 1931.

Greater New York December meeting for Better Dentistry, December 1-5.

STATE SOCIETIES

District of Columbia, at George Washington University, Washington, D. C., second and fourth Tuesdays in each month from October to June, inclusive.

September

Maryland, at Ocean City (15-16).

MEETINGS OF STATE BOARDS OF DENTAL EXAMINERS

New Jersey, at Trenton, December 1-6. John C. Forsyth, Secretary, 146 W. State St., Trenton.

AMERICAN DENTAL SOCIETY OF EUROPE

The next annual meeting of the American Dental Society of Europe will be held in Paris, France, July 29-Aug. 1, 1931.

DAWSON BUCKLEY, *Secretary,*
25 Blvd. Victor Hugo
Nice, France.

STATE BOARD OF REGISTRATION AND EXAMINATION IN DENTISTRY OF NEW JERSEY

The State Board of Registration and Examination in Dentistry of New Jersey will hold its regular examinations at Trenton, N. J., commencing, December 1, and continuing for five days thereafter. The examination fee is $25; reexamination fee, $10. Practical tests required: Insertion of a gold filling in a cavity of Class 2, 3, or 4 type, the cavity to be of fair size and reasonably difficult to be acceptable, and the candidate to furnish his own patient; taking of impression, bite, selection of teeth, articulation and trial denture, the candidate to furnish his own patient; practical examination in mouth diagnosis. Attention is invited to the following quotation from the dental law of New Jersey: "Applicant shall present to said Board a certificate from the Commissioner of Education of this State, showing that before entering a dental college he or she had obtained an academic education consisting of a four-year course of study in an approved high school, or the equivalent thereof." In accordance with this law, the secretary will issue application blanks only on presentation of the required certificate from the Commissioner of Education, State House, Trenton, N. J. Application must be filed complete ten days before the date of the examinations (November 21). Address all communications for further particulars to

JOHN C. FORSYTH, *Secretary,*
148 West State St.,
Trenton, N. J.

GREATER NEW YORK DECEMBER MEETING FOR BETTER DENTISTRY

The sixth Greater New York December Meeting for Better Dentistry will be held at the Hotel Pennsylvania, New York City, December 1-5. A return post card sent to the membership of both societies including nineteen subjects which the committee considered might be of interest to subscribers, brought more than 500 replies, showing a marked interest in suggestions to the Committee for selection of clinic material. The topic discussions will again occupy an important place in the program. A manufacturers' exhibit

*Announcements must be received by the fifth day of the month in order to be published in the forthcoming issue of THE JOURNAL.

will be held in the hotel simultaneously with this meeting.

JOHN T. HANKS, *Chairman.*
CHARLES M. MCNEELEY, *Vice Chairman.*

ALUMNI, NEW YORK UNIVERSITY COLLEGE OF DENTISTRY

The Alumni Association of New York University College of Dentistry, a component of the New York University Alumni Federation, extends a cordial invitation to membership to all graduates of the New York College of Dentistry and the New York University College of Dentistry. Graduates are advised to communicate with their class delegates or Benjamin A. Ross, executive secretary, 100 Washington Square East, New York City.

SIMON SHAPIRO, *President.*
SAMUEL CHARLES MILLER, *Secretary.*

SIXTY-SEVENTH ANNUAL MEETING AND CLINIC CHICAGO DENTAL SOCIETY, FEB. 2, 3, 4, AND 5, 1931

The Chicago Dental Society extends a cordial invitation to all members of the American Dental Association to attend the annual meeting and clinic to be held at the Stevens Hotel, Chicago, Feb. 2, 3, 4 and 5, 1931.

Following is a list of the sections together with the names and addresses of the various section chairmen. It is the very earnest desire to prepare a program which will meet with universal approval. To that end they solicit constructive criticisms and suggestions which will assist them in the selection of essayists and subjects to be presented and discussed. Other suggestions for the improvement of the meeting and the comfort of visitors should be directed to the secretary.

Section I. Operative Dentistry

Chairman: A. E. Schneider, 25 E. Washington St.

Vice Chairman: E. W. Swanson, 25 E. Washington St.

Section II. Full Dentures

Chairman: Robert R. Gillis, Hammond, Ind.

Vice Chairman: J. M. Besser, 55 E. Washington St.

Section III. Partial Dentures; Crown and Bridge

Chairman: R. A. Jentzsch, 185 N. Wabash Ave.

Vice Chairman: O. W. Silberhorn, 180 N. Michigan Ave.

Section IV. Oral Pathology

Chairman: W. G. Skillen, 311 E. Chicago Ave.

Vice Chairman: Isaac Schour, 1838 W. Harrison St.

Section V. Mouth Hygiene

Chairman: Irwin G. Jirka, 3165 W. Madison St.

Vice Chairman: F. B. Rhobotham, 55 E. Washington St.

Section VI. Orthodontia

Chairman: F. B. Noyes, 30 N. Michigan Ave.

Vice Chairman: F. E. Haberle, 55 E. Washington St.

Section VII. Oral Surgery

Chairman: E. L. Dunn, 25 E. Washington St.

Vice Chairman: J. L. Meredith, 30 N. Michigan Ave.

Section VIII. Dental Economics

Chairman: John H. Cadmus, 185 N. Wabash Ave.

Vice Chairman: F. van Minden, 185 N. Wabash Ave.

Stanley D. Tylman will again be the chairman of the Program Committee assisted by Frank H. Vorhees, David W. Adams, Frank G. Conklin and M. M. Printz.

The extension of the meeting from a three to a four day session will give visitors an opportunity to attend more lectures and clinics than in past years. The large exhibition hall has again been reserved for manufacturers' and dealers' exhibits. All reservations should be directed to C. Davidson, Chairman, Exhibit Committee, 185 N. Wabash Ave., Chicago, Ill.

HARRIS W. MCCLAIN, *President.*
HOWARD C. MILLER, *Secretary,*
55 East Washington St.

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1929-1930

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